A Preliminary Summary of

Progress and Plans

POTATO RESEARCH

Of the United States Department of Agriculture
and
in cooperation with
State Agricultural Experiment Stations

Prepared for the Department's
POTATO RESEARCH AND MARKETING ADVISORY COMMITTEE

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This progress report is primarily a tool for use by advisory committee members in developing recommendations for present and future research programs and by USDA administrators for developing, coordinating, and evaluating research plans. Included in it are summaries of research done during the past year. Some are tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to advisory committee members, research administrators, and others having special interest in the development of public agricultural research programs.

The report also lists publications of research results issued during the year. Current agricultural research findings are also reported in the monthly USDA publications, "Agricultural Research" and "Agricultural Marketing."

~~UNITED STATES~~ DEPARTMENT OF AGRICULTURE
Washington, D. C.

FUNCTIONS OF ADVISORY COMMITTEES

The Potato Committee is one of twenty-five commodity and functional committees of the U. S. Department of Agriculture established pursuant to Title III of the Research and Marketing Act of 1946. Functions of the members of these committees include:

1. Acquainting themselves with the problems of producers, processors, distributors, and consumers, and presenting them for committee consideration.

2. Reviewing the current research and marketing service programs of the Department and recommending adjustments, including terminations, in the current program in order that available funds, personnel, and facilities will be used on problems of greatest importance.

3. Recommending new work or expansion of current work and indicating relative priority of such recommendations, when the current program is insufficient to develop solutions for important problems.

4. Developing a better understanding of the nature and value of the agricultural research program, explaining it to interested groups and organizations and encouraging the wider and more rapid application of the findings of research.

The committees perform an important function in advising with respect to the development of the Department's research and marketing service programs. However, committee members recognize that the development of budgets and the implementation and administration of research and marketing programs are responsibilities of the Department.

A progress report similar to this one is prepared for each committee. The areas of the other twenty-four committees are:

Citrus and Subtropical Fruit
Cotton and Cottonseed
Dairy
Deciduous Fruit and Tree Nut
Economics
Farm Equipment and Structures
Feed and Forage
Food and Nutrition
Food Distribution
Forestry
Grain
Home Economics
Livestock
Oilseeds and Peanut
Poultry
Refrigerated and Frozen Products
Rice
Seed
Sheep and Wool
Soils, Water and Fertilizer
Sugar
Tobacco
Transportation
Vegetable

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CODES TO DESIGNATE UNITS CONDUCTING RESEARCH

AGRICULTURAL RESEARCH SERVICE (ARS)

Farm Research Divisions

AE ..... Agricultural Engineering
ADP ..... Animal Disease and Parasite
AH ..... Animal Husbandry
CR ..... Crops
ENT ..... Entomology
FE ..... Farm Economics
SWC ..... Soil and Water Conservation

Utilization Research and Development Divisions

EU ..... Eastern
NU ..... Northern
SU ..... Southern
WU ..... Western

Home Economics Research Divisions

CH ..... Clothing and Housing
HHE ..... Household Economics
HN ..... Human Nutrition

AGRICULTURAL MARKETING SERVICE (AMS)

Economics and Statistics Divisions

AEC ..... Agricultural Economics
AES ..... Agricultural Estimates

Marketing Research Divisions

MD ..... Market Development
ME ..... Marketing Economics
MQ ..... Market Quality
TF ..... Transportation and Facilities

FCS ..... FARMER COOPERATIVE SERVICE

FAS ..... FOREIGN AGRICULTURAL SERVICE

FOREST SERVICE (FS)

Forest Research Divisions

FDR ..... Forest Diseases
FER ..... Forest Economics
FFR ..... Forest Fire
FIR ..... Forest Insect
FMR ..... Forest Management
FPR ..... Forest Products Utilization
FMR ..... Range Management and Wildlife Habitat
WMR ..... Watershed Management

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I. FARM RESEARCH

A. Breeding and Genetics

INTRODUCTION, BREEDING, GENETICS, AND EVALUATION CR

Problem: Develop and evaluate new and improved varieties of potatoes having high yield and quality, resistance to diseases and pests, and suitability for specific processes and uses; introduce foreign germ plasm to increase genetic base for potato improvement.

Program: A continuing long-term program of introduction of varieties and species for direct or breeding purposes, cytogenetic and genetic studies, applied breeding, selection, evaluation, and ultimate release of promising new kinds. Between nine and ten professional man-years per year of Federal work is devoted to this problem at Beltsville, Maryland; Presque Isle, Maine; Madison, Wisconsin; Greeley, Colorado; Prosser, Washington; Aberdeen, Idaho; Baton Rouge, Louisiana; and Weslaco, Texas. Cooperative work is also conducted with State agricultural experiment stations at 25 additional places.

Progress: Plant introduction and development. During the past year, 810 introductions of potatoes and closely related species have been received from Mexico and other foreign sources. During their quarantine detention at the U. S. Plant Introduction Station, Glenn Dale, Maryland, they are indexed for virus diseases. As released from quarantine, they are distributed to Federal and State research workers. Part of each will be added to the germ plasm collection maintained at the U. S. Potato Introduction Station, Sturgeon Bay, Wisconsin.

Breeding. New varieties. A scab and late blight resistant red is being released under the name, Catoosa. This was developed primarily for the southern potato-growing areas and is cooperatively released with Louisiana and Tennessee. This variety is the first red released with resistance to both scab and late blight. The variety Norland (cooperative with North Dakota) released in 1958 has found widespread grower acceptance. The varieties Navajo and Blanca were released cooperatively with Colorado to satisfy demands for scab resistant varieties for the Southwest. These are both white-skinned with round tubers similar to Katahdin. Solids are superior to Katahdin. Cooking and chipping qualities of both Navajo and Blanca are good.

Another release is Erendira which was developed for growing as an unsprayed crop in central Mexico where late blight is especially severe. Yields of about 400 bushels per acre have been obtained with this variety where susceptible unsprayed checks yielding nothing. (Coop. Mexico)

Promising selections. A selection scheduled for early release and naming is B 2368-4. It compares favorably with Red Pontiac in season, yield and characteristics, but is an improvement over Red Pontiac in that

it is highly scab resistant. The improvement in scab resistance should reduce culls because of pitted scab lesions by at least 20 percent. In Maine it yielded 858 bushels per acre, higher than any other variety or selection. Solids compared favorably with Red Pontiac. In trials in Texas, B 2368-4 was the outstanding selection.

Quality tests. Three selections produced light-colored chips and fries after 38° F. storage and reconditioning. Many selections made satisfactory chips and fries when processed immediately after harvest.

Scab resistance. A total of 1,037 seedlings and 88 varieties were tested for scab resistance. Several selections were found to have high scab resistance ombined with other important horticultural and disease-resistant factors.

Verticillium wilt. Of 491 selections tested for wilt resistance, 24 percent showed no infection in the field. In a wilt-yield test, Ontario ranked first in yield (610 bushels) and lowest in wilt infection (2 percent). Cobbler had the lowest yield (279 bushels) and the highest infection (83 percent).

Net necrosis and stem-end browning. Several varieties and selections were compared for yielding ability and for susceptibility to tuber necrosis (leafroll) and stem-end browning. B 2368-4 yielded 740 bushels per acre and showed no symptoms of tuber necrosis and Plymouth, 13 percent infection with stem-end browning.

Leafroll resistance. Field testing for leafroll resistance in 1958 included 5,340 seedlings (one hill each) and 590 selected seedlings (five hills). Of those not showing primary leafroll, 198 seedlings (3.7 percent) were saved for replanting. Outstanding selections with high leafroll resistance in past tests are being evaluated in yield tests to be used as parents and/or to be introduced eventually as commercial sorts. (Coop. Maine)

Golden nematode resistance. Approximately 2,200 seedlings that are segregating for golden nematode resistance were grown in 1957. Seventy-five of these were selected, replanted in 1958 and tested on Long Island. Twenty-four showed continued resistance. (Coop. New York)

Ring rot resistance. About 650 five-hill selections segregated for ring rot resistance were tested. Also, 15 superior selections with known ring rot resistance and five susceptible varieties were compared for yielding ability. Eight of the 15 selections yielded over 600 bushels of U. S. No. 1 tubers per acre and also had desirable cultural and cooking qualities. (Coop. Maine)

Black spot. Seedlings are being rated for bruising color intensity and internal necrosis. Symptom expression apparently is dependent on a number of factors and testing over a period of years is required in order to obtain reliable results.

Approximately 200 selections were grown for the first time and 66 selected for further bruising tests. Twenty-three advanced selections were yield tested and compared to a standard check. Most of these have made satisfactory chips in previous tests. (Coop. New York)

Pacific Northwest. Over 650 clones were rated for maturity and verticillium wilt resistance in 1958. Many of these selections were also tested for resistance to fusarium, scab, leafroll, viruses X and A, and heat necrosis. From approximately 10,000 seedlings grown in 1958, 400 were selected for further testing. Many promising seedlings were compared for yielding ability, for verticillium wilt resistance and for processing characteristics (Coop. Idaho)

North central region. Indexing each tuber at Ames, Iowa, and Homestead Florida, was started in 1958. The effect of this program was apparent in the field this year when almost no visible virus symptoms appeared on the plants. The control of virus spread by this double-check procedure was excellent. (Coop. Iowa)

Breeding for insect resistance was continued in 1958. It was found that resistance to leaf hoppers and to flea beetles is not associated and two types of resistance are involved. The source of flea beetle resistance was found chiefly in Solanum chacoense. (Coop. Iowa)

Southern region. The objective of the breeding program in the South is to develop new varieties that are well adapted to southern growing conditions and that possess desirable horticultural and culinary qualities and disease resistance. Fifteen Tennessee-grown seedlings were planted in the Southern States. Nine yielded over 400 bushels of U. S. No. 1 tubers per acre and six over 500 bushels. Nine of these selections are being increased in three Northern States. (Coop. Louisiana)

Sturgeon Bay. Eighty-four new stocks were received through expeditions to (1) Mexico and South America (expedition led by D. S. Correll of the Texas Research Foundation) and (2) Mexico and Central America (led by J. G. Hawkes, University of Birmingham, England). Only a part of the material from these expeditions is not in the Inter-Regional Collection; the remainder is being processed through quarantine at Glenn Dale, Maryland. Shipments of seeds and tubers were made to 16 States and seven foreign countries. Total shipments included 240 seed samples, 638 tuber samples, and 31 dried-foliage samples. (Coop. IR-1)

Texas, Crystal City. About 10 acres of potatoes are being grown for evaluation tests at Weslaco, Harlingen, Crystal City, Prairie View, and Bryon locations. Over 23,000 single-hill tubers are being grown for selection in Texas and increasing in Maine for replanting in 1959 in Texas. Several hundred selections from Iowa and Maine have been divided and are also being grown at these locations for adaptation studies and eventual selection. Thirty-one selections from material grown and selected in Texas last year were increased in Maine and are now being grown again in Texas for reselection. (Coop. Texas)

Commercial tests of seedling B 2368-4, Kennebec, and Pontiac are being conducted. So far, B 2368-4 has shown much promise as a commercial sort. (Coop. Texas)

Washington, Prosser. Many advanced selections were planted at Prosser and exposed to leafroll. Selections from these plots will be replanted and re-examined there in 1959. A virus-free potato program was started in co-operation with the Washington State Seed Commission at Bellingham. A few foundation seed growers were supplied with virus-free seed of Kennebec and Norland. Tests this year at four locations indicated that Norland may be adapted to the Northwest. (Coop. Washington)

Potato cytogenetics. Detailed cytological investigations were made of several clones of 11 diploid species and 67 diploid interspecific hybrids at Beltsville, Maryland, in 1958. Thirty artificial tetraploids representing six species and 24 hybrids were successfully crossed with cultivated varieties.

The work at Wisconsin included a detailed study of haploidy in the common potato. Twenty of the original 29 haploids obtained in 1957 were propagated and studied for morphological characters, meiosis, and intra- and interspecific crossability. Twenty of the haploids flowered and 19 have been used successfully as female parents in intra-haploid matings or in matings with tuber-bearing diploid (2N=24) Solanum species. Two of the haploids are highly male fertile. Approximately 105,000 seeds were obtained from matings of haploids with 23 diploid Solanum species and small populations have been grown from 88 of these combinations. (Coop. Wisconsin)

Plans: Work will continue along present lines and at substantially the present scale. As new selections emerge that appear worthy of release, they will be made available to growers. Continued stress will be made toward the improvement and maintenance of the highest possible quality of both fresh and processed potatoes as they reach the consumer. This includes studies from the standpoint of breeding toward improvement of after-cooking discoloration and black spot.

Exploration and introduction of potatoes will continue. Recommendation from advisory committees, research agencies, and related groups will provide the means of efficienc planning to meet future research needs.

Publications: Maine Potato Variety Trials for 1958. H. J. Murphy, M. J. Goven, and A. E. Schark. Maine Agric. Exp. Sta., Misc. Pub. 636, Feb. 1959.

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Haploids of the Common Potato. R. W. Hougas, S. J. Peloquin, and R. W. Ross. Jour. of Heredity 49: 103-107. 1958.

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Genetic Variation Among Haploids of the Common Potato. R. W. Hougas and S. J. Peloquin. Am. Potato Jour. 35: 722 (Abs.) 1958.

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Fertility in Two Solanum Tuberosum Haploids. S. J. Peloquin and R. W. Hougas. Science 128: 1340-1341. 1958.

The Use of Decapitation in Interspecific Hybridization in Solanum. S. J. Peloquin and R. W. Hougas. Amer. Potato Jour. 35: 725 (Abs.) 1958.

Cytology of Solanum Tuberosum Haploids. S. J. Peloquin and R. W. Hougas. Bot. Soc. Am. Ann. Meet. (Abs.) 1958.

Induced Polyploids of Solanums and Their Crossability with S. Tuberosum. M. L. Magoon, D. C. Cooper, and R. W. Hougas. Bot. Gazette 119: 224-230. 1958.

Cytogenetic Studies of Tetraploid Hybrids in Solanum. M. L. Magoon, R. W. Hougas, and D. C. Cooper. Jour. Heredity 49: 170-177. 1958.

Cytogenetic Studies of South American Diploid Solanums Section Tuberarium. M. L. Magoon, R. W. Hougas, and D. C. Cooper. Am Potato Jour. 35: 375-394. 1958.

Cytogenetic Studies of Some Diploid Solanums Section Tuberarium. M. L. Magoon, D. C. Cooper, and R. W. Hougas. Am. Jour. Bot. 45: 207-221. 1958.

Nordak and Norgleam: Two New White-Skinned Potato Varieties with Early Maturity and Field Resistance to Virus Y. R. H. Johansen, N. Sandar, W. G. Hoyman, and E. P. Lana. Am. Potato Jour. 35: 774-777. 1958.

Norland, A New Red-Skinned Potato Variety with Early Maturity and Moderate Resistance to Common Scab. R. H. Johansen, N. Sandar, W. G. Hoyman, and E. P. Lana. Am. Potato Jour. 36: 12-15. 1959.

B. Physiology and Nutrition

FERTILIZERS AND PLANT RESPONSE CR

Problem: Potato yields have increased to the level where certain limiting yield factors begin to operate. Basic relationships between nutrient absorption and plant responses are needed to understand the nature of these limiting factors in potato production and their effects on the potato plant.

Program: This is a continuing long-term program involving potato fertilizers, their placement, formulation, and application; soil and plant tissue testing, and physiological responses of the potato plant, particularly with reference to the quality and yield of the tubers. This work is being done primarily at Beltsville, but cooperative work is conducted in several States, particularly Colorado and Maine. At present, one professional man-year per year of Federal work is devoted to this problem.

Progress: A factorial experiment at Presque Isle, Maine, designed to study simultaneously the field response of four varieties to rate of fertilizer application and seed spacing was continued. Results indicate only small effects on yields were obtained from 200-pound increments of 10-15-15 fertilizer ranging from 800 to 1600 pounds per acre. Fertilizer rates had no effect on number of tubers per hill but the higher rates did affect the average weight of the tuber. Number of tubers per hill and their size decreased as seed spacing was reduced from 12 to nine and six inches. Yields were increased, however, due to the greater number of plants at the narrower spacing. This effect was not uniform for all varieties. Saco and Kennebec were more responsive than Merrimack to intensive cultural practices. Closer seed spacing can be used to avoid oversized tubers while increasing yields.

Plans: The potato nutritional work will be continued and a report prepared on the above experiment.

Publications: Procedure for Comparing the Field Performances of Potato Varieties Including Financial Returns from Seed and Fertilizer Use. G. V. C. Houghland and R. V. Akeley. Am. Potato Jour. 35: 722 (Abs.) 1958.

Effects of Seed Spacing and Fertilizer Rate on Field Performances of Potato Varieties and On Financial Returns. G. V. C. Houghland and R. V. Akeley. Am. Potato Jour. 36: 227-234. 1959.

C. Cultural Practices

POTATO CULTURE CR

Problem: Devise methods of planting, seed cutting, and other cultural practices which will culminate in greater efficiency of use of labor and natural resources.

Program: Part of a continuing program of long standing research involving methods of planting, spacing, seed preparation, soil preparation, cultivation, and harvesting. Less than one professional Federal man-year per year is being devoted to problems of potato culture, with present emphasis on precut seed.

Progress: The effect of seedpiece dehydration on the yields of four varieties was studied. Germination and yields were adversely affected by the dehydration method used. Kennebec, the least affected, had the highest yield per acre (488 bushels) when 30 percent moisture (by weight) was removed. Sebago, the most affected, had the lowest yields (37.4 bushels). The effect of seed-cutting dates on yields varied for the different varieties and for dates of cutting. There was no significant difference in yield between cutting dates for Irish Cobbler.

Precut seed is being accepted commercially and in 1958 about 60 carloads of precut seed was processed.

A summary of three years' work on twin row planting was prepared for release to growers as a mimeograph.

Plans: Early precutting of seed seems to hold promise and research will be continued.

Publications: Effect of Seed-Cutting Dates on yield of Potato Varieties. R. V. Akeley. Am. Potato Jour. 35: 721 (Abs.) 1958.

SOIL AND WATER MANAGEMENT AND CONSERVATION SWC

Problem: Potato growers are confronted with problems of devising methods of irrigation, prevention of soil and water losses through erosion and developing soil management and crop rotation systems under which potatoes can be grown economically.

Program: A continuing program of research on soil and water conservation conducted in potato-growing areas in cooperation with the State Experiment Stations in Maine, Washington, Idaho, Utah, and Montana and involving about two professional man-years annually.

Progress: A summary of sprinkler versus gravity irrigation during the period from 1949 to 1956 at Logan, Utah, has been made. Sprinklers were favored for production of No. 1 Russet potatoes, but the quality index of potatoes was higher with furrow irrigation.

In order to understand more clearly the significance of soil aeration, the respiration processes of the center cells of potato tubers were studied in Illinois. Preliminary investigations revealed that finite transfer of oxygen through the tuber tissue was insufficient to account for the observed respiration rates. This indicated that the respiration was probably

maintained not by movement of oxygen inward, but by movement of electrons outward. When the center cells of the potato were exposed, however, oxygen per se was essential for respiration. Bathing this exposed tissue in water that was de-gassed or saturated with N_2 or CO_2 effectively prevented respiration.

A study of the fertilizer-use data reported in the 1954 Census showed that the proportion of potato and sweet potato acreage fertilized was 78 percent and that these crops received an average of 277 pounds of primary nutrients per acre.

Plans: Investigations will be continued to develop winter soil cover following late potatoes and to determine the influence of mulches on soil temperature and on yield and quality of potatoes, and to improve the fertility status needed for sustained yields of potatoes.

81% of U. S. Potato Acreage Fertilized, USDA Study Shows. VII. Potatoes. J. R. Adams, L. B. Nelson, and D. B. Ibach, Croplife 5(39): 1, 20 (1958)

D. Disease and Nematode Control

DISEASE CONTROL CR, ENT, SWC

Problem: Determine the nature of causal agents of diseases, how they infect, spread, carry-over, and better ways of diagnosing their presence; develop practical methods of avoiding or controlling diseases through breeding, crop and soil management, or other means including fungicides, bactericides, nematocides, and insecticides.

Program: A continuing long-term program involving primarily basic research on the nature of specific diseases of virus, fungus, and bacterial origins, the nature and behavior of the causal agents, methods of diagnosis, new methods of research. About five professional man-years per year of Federal work is devoted to this problem at Beltsville, Maryland; Fort Collins, Colorado; Madison, Wisconsin; Baton Rouge, Louisiana; Ithaca, New York; Presque Isle, Maine; Fargo, North Dakota; and Ames, Iowa. Work with State experiment stations also is conducted at 12 other locations.

Progress: Virus A. At Beltsville, Maryland, of 224 selections screened for immunity from virus A, 78 selections were graft-immune and 68 were aphid-immune from the virus.

Virus X. At Presque Isle, Maine, of 817 selections screened by mechanical inoculation for resistance to a virulent strain of virus X, 190 failed to become infected. At Beltsville, Maryland, 69 plant introductions of Solanum tuberosum (andigena) were screened for resistance to virus X by mechanical inoculation. Fifteen selections failed to become infected.

At Madison, Wisconsin, a previously undescribed yellow strain of virus X was discovered and found to be sufficiently different from the mottle, ringspot, and brownspot groups to warrant its separation into a yellow group. Varieties Tawa and Saco and seedling 41956 are immune to this strain of the virus, although the virus can, in some cases, be recovered from the roots after top graft with infected scions.

Virus Y. At Presque Isle, Maine, and Beltsville, Maryland, 602 selections and varieties were screened for resistance to virus Y by aphid inoculation. Seventy-five selections failed to become infected under field conditions. Selections from progenies of several parental combinations proved resistant to virus Y under the conditions of the test. Sixty-eight plant introductions of S. tuberosum (andigena) included in the test were susceptible to infection.

At Beltsville, one selection of S. antipoviczii, three of S. chacoense, three of S. stoloniferum and one of S. verrucosum var. spectabilis proved immune from virus Y by graft inoculation. At Madison, Wisconsin, several selections of S. stoloniferum were found to be immune from aphid, graft, and mechanical inoculation to 14 isolates of virus Y. The inheritance of immunity from virus Y in S. stoloniferum is being studied.

Corky ringspot. The corky ringspot disease was shown to be caused by a soil-borne virus which has been named "potato corky ringspot virus." The virus has been recovered from infected potato tubers and virus-containing soil, and its serological relationship with a soil-borne potato virus of the Netherlands has been established. This is the first record of a soil-borne virus of the potato in the United States. At Beltsville, physical properties and transmissibility of the corky ringspot virus were found to be similar to those of the soil-borne virus causing potato stem mottle in Holland and other foreign countries. Infected seedpieces were found capable of infesting steamed and unsteamed greenhouse soil.

Virus S. At Madison, Wisconsin, recent tests indicate that immunity from virus S in Saco is transmitted to some extent in progenies of selfs and crosses. Some 65 hosts failed to yield a good local lesion indicator plant for virus S.

Leafrolling mosaic virus. At Madison, Wisconsin, recent investigations with the leafrolling mosaic virus from the Schultz Potato Virus Collection indicate that this virus now forms the basis for a new group of potato viruses. Interveinal Mosaic of Cobbler (U. S.), King Edward Paracrinkle (England), Fortuna Mosaic (Germany) and Bintje Mosaic (Holland) were shown to be closely related strains of the leafrolling mosaic virus.

Aucuba mosaic virus. At Beltsville, Maryland, a virus isolated from potatoes grown in Florida was found to be closely related to the potato aucuba mosaic virus. This is the first report of the occurrence of this type of virus in the United States since 1925.

Vein net. At Beltsville, six potato varieties were shown to be highly susceptible to this aphid-borne virus.

Leafroll. At Presque Isle, Maine, 13 leafroll-resistant selections, three varieties, and 67 plant introductions of S. tuberosum (andigena) were evaluated for resistance to the leafroll virus under field conditions. Five selections from the Beltsville program showed a high level of resistance under the conditions of the test. The named varieties and plant introductions all became diseased. At Fort Collins, preliminary investigations indicated that the chipping quality of potato tubers infected with leafroll and spindle tuber viruses was not inferior to that of healthy tubers.

Spindle tuber. At Presque Isle, Maine, 69 plant introductions of S. tuberosum included in the spindle tuber tests were susceptible.

Scab. At Presque Isle, 69 plant introductions were screened for resistance to scab in comparison with the scab-resistant variety Cherokee. Thirteen introductions were equal to, but not superior to, Cherokee in resistance to scab. At Fort Collins, Colorado, 156 selections, previously selected for scab resistance by the ferric chloride test, were grown in scab-infested soil. Ninety-nine selections were highly resistant, 35 showed moderate resistance and 22 were slightly more resistant than the susceptible control.

At Fort Collins, Colorado, studies on the antagonism between different fungi and isolates of Streptomyces scabies was continued. One isolate of Streptomyces scabies obtained from soil from Surinam proved antagonistic to all but one of 53 different fungi. The antifungal properties of this isolate of Streptomyces is being investigated further.

At Fort Collins, Colorado, further investigations showed the effectiveness of Terraclor (PCNB) in controlling scab and Rhizoctonia in infested soils at rates below the phytotoxic level of the chemical.

Laboratory studies by SWC on soil and microbial factors affecting the survival and growth of the potato scab organism Streptomyces scabies at Prosser, Washington, showed that 29 isolates of the organism collected from various potato-growing areas in the United States did not show much variation in cultural characteristics. All the naturally occurring forms appeared to be melanin producers. S. scabies is sensitive to almost all of the commercially available antibiotics except penicillin and polymyxin. It is also sensitive to antibiotic effects from a high percentage of actinomyces occurring in soil. The different isolates are usually sensitive to antibiotic effects from each other, but clones are insensitive to their own antibiotic products. Examination of the microflora growing directly on potato tuber surfaces or in soil adherent to tubers was made in an effort to explain the scab-controlling effect associated with certain soils under study. It was found that there was no significant difference in the total numbers of bacteria or actinomyces associated with tubers grown in suppressing or nonsuppressing soils. Nor was

there any difference in the numbers of antibiotic organisms. Similar negative results were obtained in examination of antibiotic effects associated with organic debris in two types of soil. The basis of scab suppression by some soils remains unknown, but may be connected with differences in tuber susceptibility. A direct assay procedure for determining populations of the potato scab organism was developed. This method makes use of the pigment-producing action of S. scabies tyrosine-nitrate medium plus its sensitivity to inhibition by other soil actinomyces. The method was used to follow the change in population of S. scabies when inoculated in scab-suppressing and nonsuppressing soil. It was found that populations decreased in 38 days to less than 20 percent in both soils, and survival was no better in nonsuppressing soil.

Verticillium wilt. At Presque Isle, Maine, crop rotation studies for the control of Verticillium wilt of potatoes indicate that oats and millet are superior to clover in three- and four-year rotations with potatoes for the control of the disease.

Late blight. At Presque Isle, 1131 selections were screened for resistance to Phytophthora infestans in the greenhouse and the field. Race "0" was used as the inoculum, however, 13 additional physiologic races appeared in the field during the season. Of the 435 selections susceptible to race "0" in the greenhouse, 11 were slightly more resistant in the field, 87 were moderately resistant, and 238 were slightly more resistant than the susceptible controls. Of the 624 selections that were immune to race "0" in the greenhouse, 43 failed to become infected, 10 were highly resistant, 55 were moderately resistant and 173 were slightly resistant to infection in the field.

Late blight warning service. Epidemiological research planned to increase the accuracy of forecasting methods was continued at three locations, in cooperation with State agricultural experiment stations, at Raleigh, North Carolina, for the southeastern region; at Newark, Delaware, for the northeastern region; and at Ames, Iowa, for the northcentral region.

In the northcentral region, laboratory and field studies on the factors involved in the development of potato late blight were continued. The response of eleven differential potato varieties to inoculation with three related isolates of Phytophthora infestans showed that each isolate comprised more than one race of the fungus. Three "blight gardens" were planted using hypodermically inoculated certified Irish Cobbler tubers. In one blight garden a lesion of late blight was found 39 days after emergence and 43 days later 95 percent of all foliage was blighted. Regional forecasts of late blight occurrence in the northcentral region were issued regularly from Ames.

In the southeastern region forecasts of late blight were made on the basis of hygrothermograph records of temperature and relative humidity received from cooperators in the various potato- and tomato-growing areas. Predictions that infection would be expected to appear were generally accurate.

In the northeastern region the forecast service was expanded to include Rhode Island, Long Island, central New Jersey, Pennsylvania, and northeastern Ohio. Close cooperation was maintained with Dr. Reiner Bonds who made forecasts from Maine. At most stations, both time of first observation and ultimate amount of blight agreed closely with the forecasts.

Disease control. A disease control plot was conducted at Greeley, Colorado, in 1958 to test the effect of insecticides, early roguing, and early maturity on the spread of leafroll, mosaic, spindle tuber, "aster yellows," and virus Y. Current-season spread was reduced by one early spray of a systemic insecticide. Late-season spread of leafroll was not controlled and a 35 percent infection occurred on the late-maturing varieties by September 20. Necrosis symptoms from "aster yellows" spread was 41 percent in rows adjacent to diseased ones and 58 percent within a radius of six feet. Samples were saved for field indexing in 1959.

Publications: The Serological Relationships of Potato Viruses S and M, and the Carnation Latent Virus. R. H. Bagnall, C. Wetter, and R. H. Larson. (Abs.) Phytopath. 48: 391. 1958.

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NEMATODE CONTROL CR

Problem: In addition to the well-known golden nematode of potatoes and the potato rot nematode, potatoes in all parts of the country are attacked by root lesion nematodes and root-knot nematodes which cause reduction in growth and yield and increase the percentage of culls.

Program: A long-term program of basic and applied research is being conducted at Madison, Wisconsin, and Weslaco, Texas, in cooperation with the State Experiment Stations and involves one professional Federal man-year annually.

Progress: On Long Island, it was found that ionizing radiation will probably be of no practical use in control of the golden nematode of potatoes, because of the very high dosages required for significant effects on the nematodes. It was also determined that the males of the golden nematode are necessary for reproduction. In Wisconsin, roots of stunted potatoes growing in the field were found to be heavily infected by a root lesion nematode, but this nematode was not found in the tubers.

Plans: Work on the golden nematode is being taken over by Cornell University. Other work will be continued at about the present level.

Publications: Impracticability of Control of Plant-Parasitic Nematodes with Ionizing Radiation. R. F. Myers and V. H. Dropkin, Plant Dis. Reptr. 43: 331-333. 1959.

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E. Insect Control

INSECTS AFFECTING POTATOES ENT

Problem: Potato growers have to contend with many kinds of insects, several hundred species being known to feed on the potato in the United States. Work is needed to develop more effective and economical and less objectionable methods of control with particular reference to avoiding the accumulation of excessive insecticide residues in the soil and on the crop. Work is particularly needed on the green peach aphid as a pest of potatoes, the southern potato wireworm, the Colorado potato beetle, and the potato flea beetle because of apparent increased resistance of these insects to available insecticides.

Program: A continuing long-term program involving basic studies on the ecology, physiology, and pathology of insects that attack potatoes in the field as well as applied research on their control conducted in Washington, Maine, and South Carolina, in cooperation with the respective experiment stations, the Washington State Department of Agriculture, the Washington State Potato Commission, and industry, and involving about six professional Federal man-years annually.

Progress: Wireworms. Basic studies on the biology and habits of the southern potato wireworm have pointed the way to important improvements in methods of controlling this No. 1 insect pest of potatoes in the Southeast.

Unlike other wireworms, this insect feeds near the soil surface and has two generations per year. The research showed that the brood that damages potatoes in the spring comes from eggs laid under vegetation the previous fall. Subsequent field tests showed that either clean fallow in the fall or the application of parathion granules to the undisturbed cover crop early in the fall will prevent damage to spring potatoes. The granular insecticide sifts through the foliage to the soil where it can do most good and leave little or no residue on the cover crop. The insecticide does not need to be worked into the soil unless the soil has been disturbed since egglaying. This is in sharp contrast to the conventional procedure of working insecticides deep into the soil.

The search was continued for effective chemicals for the control of the southern potato wireworm in the areas in the Southeast where it has become highly resistant to chlordane, aldrin, heptachlor, and dieldrin. DDT at 20 pounds per acre gave reasonably good control in South Carolina but was less persistent and less effective in soils of high organic content. Parathion continued to show a high degree of toxicity to the insect but its short residual action is a big disadvantage and more information is needed on when and how to apply it. Small field-plot tests showed ethylene dibromide and four experimental materials to be about as toxic to the wireworm as parathion. Of these Diazinon showed most promise for early approval. The others were Am. Cyanamid 18,133, a phosphorus material developed as a nematocide; Shell SD 4402, a chlorinated hydrocarbon; and phorate (or Thimet), which is a systemic phosphorus material. All have good residual effect except phorate and ethylene dibromide.

Aphids and other foliage insects. Thiodan and endrin continued to give good control of the green peach aphid on potatoes, both commercially and in the field experiments. Thiodan was especially effective in the irrigated northwest where parathion and DDT have not beensatisfactory. Further evidence was obtained that Thiodan kills by fumigation as well as by contact and is relatively harmless to some of the predators of aphids. Thiodan dusts and sprays continued to be effective applied by aircraft and were more effective than granules. Thiodan dust was more effective in field experiments with ground equipment than Thiodan emulsion spray or misible Thiodan oil spray, especially when the dust contained 50 percent of sulfur. Very promising experimental results were obtained with ethion, Di-Syston, Dibrom, and Phosphamidon, and less promising results with Trithion, Korlan, Sevin, Delnav, demeton, and Diaxinon. Practically no control of aphids was obtained with barthrin or Kelthane. The four different species of aphids on potatoes varied considerably in susceptibility to the different insecticides.

In Maine, promising results were obtained for the second year on an experimental basis with cultural practices for the control of aphids on potatoes. The field experiments showed that the seasonal level of aphid infestation on potatoes was influenced by both the time of planting and the time of hilling (cultivation). Previous studies had indicated that the ultimate size of the aphid population on potatoes is determined largely by

the number that reach the young plants early in the season. By late planting and hilling to keep the new growth covered with soil, the plants were prevented from being available to the aphids during most of the spring migration period. These two practices resulted in reductions of 77 percent of the green peach aphid. These methods of control are in the experimental stage of development.

Tests conducted in Oregon jointly with the Agricultural Engineering Research Division on control of aphids with endrin and Thiodan applied by aircraft showed that net dosages and other things being equal, 10 gallons gross of spray per acre gave substantially better control than 5 gallons. These tests also demonstrated that applications under windy conditions (6-8 miles per hour) were at least as effective as those made under the ostensibly more favorable low-wind conditions (less than 3 mph). An attempt was made to correlate aphid kill on individual rows with actual spray deposits found on the foliage. While the results were not entirely conclusive, aphid control tended to be greatest in the rows with the highest deposit rate. Poor control was especially noticeable in the rows on the right of the center line of flight--a zone invariably characterized by a lighter than average rate of deposit.

Both Thimet and Phosphamidon gave promising results against the iris whitefly on potato in Washington and appeared to be more effective than Trithion, Dibrom, Korlan, Delnav, Phosdrin, Diazinon, or Tedion.

Plans: The work under way will be continued at about current levels with special emphasis on basic studies on the problems of increased resistance to insecticides and on the development of other means of control, especially by cultural methods and by the utilization of diseases and other biological enemies of the insect pests.

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INSECT VECTORS OF POTATO DISEASES ENT, CR

Problem: Most of the virus diseases of potatoes are transmitted by insects, and without the vectors would be of little importance. It should be possible to develop methods of controlling disease spread and severity through control of the insect vectors but first it is essential to develop basic knowledge on the identity, distribution, and ecology of known or suspected insect vectors; and on host plant relationships, such as the identity of alternate plant reservoirs for the viruses, and acceptability of the reservoirs for vector feeding.

Program: A basic long-time study requiring a coordinated team approach by entomologists and pathologists. Current studies are incidental to related problems in Maine, Colorado, and Washington, in cooperation with the respective State Experiment Stations and the Wisconsin Agricultural Expermental Station, involving less than one professional man-year annually.

Progress: Lists of reported vectors of the virus of purple top disease of potato, better known as aster yellows; plant reservoirs of the virus; and host plants of the best known vector, the six-spotted leafhopper, have been assembled for publication. A study of the ecology of this leafhopper has extended our knowledge of its overwintering or spring breeding areas and its long distance movements into the North Central States.

Plans: Work along the lines indicated will be continued.

F. Mechanization of Production and Harvesting

PEST CONTROL EQUIPMENT AE, ENT

Problem: There is need for work on the reduction of cost and the improvement of effectiveness of pest and weed control equipment by the development of improved methods and equipment for use with aircraft, surface, and soil working machines.

Program: A continuing long-term program involving laboratory and field studies of equipment for control of plant diseases, insects, and soil inhabiting pests aircraft, ground, and soil working equipment, work on spray droplet sizes, and on the behavior of aerosols, was conducted with headquarters at Forest Grove, Oregon; Columbia, Missouri; St. Paul, Minnesota; Toledo, Ohio; Beltsville, Maryland; and Ames, Iowa, in cooperation with the Washington State Potato Commission and State Agricultural Experiment Stations of Washington, Oregon, Missouri, Minnesota, Ohio, and Iowa, involving about five professional Federal man-years annually.

Progress: Aircraft Application on low-growing crops. Joint studies by agricultural engineers and entomologists on spray deposit patterns were continued for low-flight levels using agricultural aircraft of different types to determine the effect of nozzle placement, speed, height of flight, and use of extended flaps on the deposit patterns produced. The basic pattern produced by spray delivered from each one foot interval of boom segment on a Rawdon T-1 airplane was determined. With uniform nozzle spacing, the use of flaps did not affect the pattern from Rawdon T-1. Distribution from uniform nozzle spacing was not as good from this aircraft as from N3N or Stearman aircraft with similar equipment and operating conditions. The AG-2 Transland gave good spray distribution over 80 feet with or without flaps at low flight elevation and over 115 feet at flight heights of 25 feet or over.

Excellent control of green peach aphid on potatoes was obtained from eight aircraft spray applications made at weekly intervals beginning when aphids first appeared.

Since it has been found that degree of spray atomization is an important factor in some types of insect control, techniques for determining atomization have been improved. A method was developed for estimating in the field the mass median diameter of a spray sample by measuring the five largest spots it produces on a dyed paper card. This was made possible by more accurate spread factor determinations and by correlation of the mass median diameter to the largest drop diameter.

In joint studies by agricultural engineers and entomologists, spray applications were made for the control of the green peach aphid to determine the relative effectiveness of different methods of applying sprays. Results indicated that overhead nozzles alone were not effective when used to spray for control of the green peach aphid on potatoes. Oil burner nozzles spraying into an air stream was not as effective as spraying with hollow cone nozzles delivered from the same location. The best control was obtained from a combination of flat spray nozzle mounted overhead and hollow cone nozzles mounted laterally and directed upward at an angle for underleaf coverage. No arrangements of spray nozzles thus far tested is fully satisfactory for controlling populations of the aphids at the top and middle foliage levels.

Control of soil inhabiting pests. A considerable number of different fungicides, insecticides, and herbicides were applied to muck, loam, and sandy soils where vegetables, forest tree seedlings, nursery stock, and ornamentals were to be grown. A rotary tiller modified to treat rows was used. A field cultivator with coiled shank type of tooth and backswept knives was also assembled for row treatments. In order to facilitate the handling of chloropicrin in shipping containers, a hinged cradle clamp mounted on the field cultivator applicator was constructed and found to be quite useful. In order to improve the convenience and certainty of its application, the addition of a dye to this material was found to make its presence in liquid form more readily visible. A number of methods for sealing the surface to retain volatile materials were tested. These included water seal, drags, or rakes to smooth the surface and polyethylene film cover.

Applications of DD soil fumigant to investigate the possibility of Golden nematode eradication were made to plots on Long Island, New York, where potatoes are to be grown. The applications were made with a chisel-type applicator with points spaced at 10-inch intervals. Applications were made without mechanical difficulty but results will not be known until next season.

Small particle behavior. A study was continued to provide basic theoretical concepts and experimental data needed for development of pesticide application equipment and techniques which have optimum depositing efficiency and distribution characteristics. Considerable progress as made in describing the behavior of groups of small particles mathematically Because of the effect of particles upon each other, it has been found that behavior of groups of particles cannot easily be predicted from the behavior of single particles. A formula similar to those describing flow of fluids has been developed which describes the behavior of groups of small particles.

Plans: Further work will attempt to improve uniformity of spray deposit pattern from low flying aircraft. Distribution of air and spray patterns will be improved in air blast sprayers, and higher concentrations of pesticides will be tried. Tests of the row-crop combination sprayer and duster will be continued to determine the most effective nozzle arrangements and methods of use. Study of small particle behavior will be extended.

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Thimet Provides Built-in Protection Against Potato Leafhopper. J. P. Sleasman and Orve K. Hedden. Ohio Farm and Home Res. Vol. 43, No. 312, May-June 1958, Ohio Agricl. Exp. Sta., Wooster, Ohio, p. 39.

PRODUCTION AND HARVESTING EQUIPMENT AE

Problem: Develop methods and equipment for improving production, harvesting, and on-the-farm handling of potatoes in order to lower cost and maintain quality.

Program: An applied research program involving the use of engineering principles in solving harvesting and farm handling problems is being conducted on a continuing basis at East Grand Forks, Minnesota, in cooperation with the Red River Valley Potato Growers' Association, Agricultural Experiment Stations of North Dakota and Minnesota, potato processors, farmers and manufacturers of field machinery for potatoes. Two professional man-years annually are involved in this research.

Progress: The method of seedbed preparation may affect clod formation, soil compaction, and yield. Tests showed "no preparation ahead of planting" resulted in as high yields and the same amount of clods as "conventional seedbed preparation."

"Chemical" killing of potato vines and control of tuber maturity is not entirely satisfactory. An implement for mechanical undercutting the vines which killed them quickly was tried with some success.

Comparative spillout losses in five side by side tests in two adjacent rows of potatoes showed the spillout loss was 12.5 cwt per acre with the conventional single-point blade and only 5.4 cwt per acre with the rotary rod substitute. However, draft tests show that the draft with a square rod blade substitute was 53 percent to 59 percent higher than with the blade.

A 2-1/8-inch pitch apron with rubber-covered links delivered 1.5 tons per acre less soil to the truck than the standard 1.80-inch pitch apron. However, it also delivered 490 pounds per acre less potatoes under 2 inches in diameter and 320 pounds per acre less potatoes 2 inches and over.

Most of the pallet boxes used are filled at the warehouse. A study was made to determine whether it would be better to fill pallet boxes in the fields and, if so, how it should be done. The results have led to the conclusion that over-all costs of harvesting, box filling, transportation, and placing in and out of storage cannot be reduced by substituting field filling of pallet boxes for bulk truck field loading and filling boxes at the storage site.

It was found that pre-sizing seed potatoes can increase the efficiency of seed cutting operations and improve quality of the resulting cut seed. A machine has been designed and tested for cutting seed potatoes into six

pieces. Several manufacturers have expressed interest in putting units on the market and several growers plan to use the new machine next year.

Plans: Tests on the seedbed preparation and vine killing by mechanical equipment will be repeated in order to provide additional information. Further work will also be done on harvester spillout losses as affected by digger blade and apron pitch. Studies on field filling of pallet boxes will be terminated and results published. The machine development for cutting seed potatoes will be tested further and a publication issued on the principles issued on the principles involved.

Publications: Harvesting Potatoes Mechanically. A. H. Glaves, Potato Facts, No. 10, Aug. 1958. (Published by Agricl. Ext. Serv. of N. Dak. Agricl. College and Univ. of Minn.)

Mechanical Seed Cutting and Handling of Potatoes. G. W. French, USDA, ARS Rept. 42-21, Jan. 1959.

II. UTILIZATION RESEARCH

A. Chemical Composition and Physical Properties

CHEMICAL CONSTITUENTS — EU, WU

Problem: The lack of knowledge concerning constituents of the potato, and of changes brought about in these constituents during processing, is limiting the development of new and improved potato products. Our knowledge of potato composition must be increased by studies on the isolation, identification, and quantitative determination of these constituents.

Program: A continuing program of basic research conducted at EU and WU, involving between three and four professional Federal man years annually. Cooperative studies are underway with the Idaho and Maine Agricultural Experiment Stations. The Idaho Agricultural Experiment Station, Moscow, Idaho, is studying the relation of chemical composition to textural quality under a USDA contract.

Progress: Organic and Free Amino Acids. Work was continued at EU on development of more complete extraction and precise determination of the quantities of the relatively strong acids present in potatoes. For want of qualitative and quantitative methods in the past, very little is known concerning the possible effects of cultural and storage conditions on the acid picture of potatoes. Citric, malic, oxalic, glutamic, aspartic, pyroglutamic, and phosphoric acids, which are the major non-volatile acids in potatoes, can now be determined quantitatively by a technique developed during the past year.

The EU quantitative study of the free amino acids of potato and their changes during storage and processing was also continued. Two new developments in the ion-exchange separation of these amino acids have been completed. A preparative column has been developed for use in the isolation of amino acids for characterization. An automatic amino acid analyzer has been put in operation which permits a complete amino acid analysis in each 24 hours as compared to one analysis each 4 to 6 days by the manual procedure. A method based on improvements in extraction and analytical techniques developed in the course of this project has been applied in a preliminary way to the solution of practical problems. For example, analyses of Ohio and Maine potatoes from several areas of each state, grown with and without irrigation, have shown that the amino acid pattern in general and the lysine content in particular arennot significantly altered for a particular area by irrigation. However, the potatoes from the two states were significantly different in their content of several of the amino acids. The desirability of making these amino acid analyses arose from attempts of the industry to explain differences in chipping quality.

Studies on the hydrolysis of asparagine, one of the principal free amino compounds in potato, were continued. Two compounds were isolated that appear to be structurally related but of different molecular weight. While it is likely that these compounds are formed during the processing of potatoes, they have not yet been identified. This study on asparagine hydrolysis was terminated.

Attempts were continued to interest the fermentation and food industries in using a mixture of potato amino compounds. Samples have been prepared by methods developed at EU, and these samples have been sent to cooperating companies for evaluation. A large food processing firm recently reported back that these amino compounds are of value in enhancing the flavor of processed potato products.

One of the nation's largest starch and adhesive manufacturers is building a new potato starch plant in Maine. The company plans to consider seriously the recovery of amino compounds.

Cell Wall Components. It was reported earlier from WU that methods had been developed for isolating and determining hemicelluloses, the major cell wall components of potatoes. Later studies at the Albany, Calif., laboratory with a number of varieties have shown that the hemicelluloses from the potatoes used were all composed of the same sugars, arabinose, galactose and a lesser amount of xylose, in approximately the same proportions. From these results it was concluded that the hemicelluloses from different varieties of potatoes are similar in composition and that the texture of cooked potatoes is not related to the composition of the hemicelluloses.

Research on Texture. An extensive study on the relation of chemical composition to textural quality is being conducted at the University of Idaho cooperatively with WU. Most of the analytical work has been completed, but results from the statistical correlations are not yet available.

Plans: Through informal cooperation with the Maine Agricultural Experiment Station, EU will receive Katahdin potatoes monthly over the 10 months' shipping season of the 1959 crop, the storage temperature being 40° F. Changes in the organic acids and free amino acids will be followed, using the newly developed methods. The potato protein will also be studied, and conventional determinations such as total solids and total nitrogen made. As time permits, some attention will be given to changes that occur in the free amino acid picture of potatoes as the result of the various types of processing. Work will be continued at about the present level at WU on the relation of starch and other factors to texture. The work on cell wall components has been discontinued.

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Recovery of Free Amino Compounds from Potato Starch Processing Water by Use of Ion Exchange. E. G. Heisler, James Siciliano, R. H. Treadway and C. F. Woodward. American Potato Journal, 36, No. 1, 1-11 (1959).

B. New and Improved Food Products and Processing Technology

IMPROVED PRODUCTS, PROCESSES, AND EQUIPMENT EU, WU

Problem: The utilization of potatoes in the form of processed products is limited because of lack of processes for improving quality and reducing the cost of processed potato products from stocks of varying qualities. New food products should be developed and improved processes and procedures devised.

Program: A technological, engineering, and pilot plant study of continuing duration in cooperation with potato processors in the principal potato producing states and with California grower organizations, involving 3 USDA professional man years annually and 1 professional industry-sponsored man year per year.

Progress: Flakes (Pilot Plant Research). A low free soluble starch content in potato flakes, as in other forms of dehydrated mashed potato, generally assures a good-textured mash on reconstitution. It is axiomatic that to obtain a low free starch content, very few potato cells may be broken during processing. Earlier efforts were directed in the research at EU toward better means for cell preservation during flake production. As reported last year, the degree of cell damage was materially reduced, through the discovery of "precooking" and through the development of a new type ricer.

It is recognized that some cell damage is inevitable, both during processing of mashed potato into flakes and during reduction of the size of the dry flakes for packaging. Recent efforts have been directed toward modification of the starch within the potato cells before drying, so that even if it is released, it will contribute no pastiness to the reconstituted product. By cooling potato slices after precooking at 160° F. (as reported last year) the amylose fraction of the starch within the potato cells is made less soluble (retrograded). The insolubility is retained throughout the subsequent cooking and drying steps, with the result that some starch may subsequently be released without undue adverse effect on texture.

Most recent research on modification of starch has shown that starch in flakes can be made less soluble also by typing it up with emulsifiers such as glycerol monopalmitrate, added to the mash before drying. The procedure recommended to, and adopted by, flake manufacturers is to precook the potato slices at 160° F. for 20 minutes, cool the precooked slices in water (below 75° F.) for at least 20 minutes to retrograde the amylose, and then to add to the mash sufficient emulsifier to tie up that fraction of starch still unretrograded. The amount of emulsifier required varies between 0.3% and 0.7% (on a dry solids basis) depending on the potato variety and specific gravity.

By applying these techniques, flakes of excellent texture even when cut to 1/8" size, have been made consistently from potatoes ranging in solids content from very high (23%) to very low (16%). Thus the package density of flakes can be increased to about 30 pounds per cubic foot, an important consideration for institutional use.

Flakes made by the improved techniques, including those from very low solids content potatoes, produce mash of good quality, even when reconstituted with boiling liquid. The reconstituted mash retains good texture, color and flavor when held on the steam table for upwards of four hours.

Under a Memorandum of Understanding with California Long White Potato Advisory Board, and the Kern County Potato Growers Association, lots of California potatoes were tested in the Eastern Utilization Research and Development Division's pilot plant for suitability as raw material for the flake process. These lots included both Winter and Spring crop potatoes dug between February and August. One lot each of Pontiacs and Kennebecs were tested; all others were Long Whites. All lots yielded flakes of high quality.

One lot of Fall crop Red McClure variety from Colorado, and one lot each of Cobbler and Pungo varieties from Virginia dug in June and July were tested and found satisfactory for flake manufacture.

A Short Term Memorandum of Understanding with the Continental Baking Company has been set up to conduct studies on the use of potato flakes in frozen dinners.

Field trips were made by EU personnel to potato flake plants in Wayland, New York, Detroit, Michigan, Grand Forks, North Dakota, and Park River, North Dakota, to aid in operations.

Flakes (Industrial Status) During 1958-59 processing season, eight potato flake plants in six states were operating. Estimated total capacity of the plants as operated last season is 28-1/2 million pounds of flakes per year.

For the coming processing season, productive capacity is being increased in several plants which were in production last year. Several new plants are expected to be in operation also, one in New York State, one in Minnesota, one in North Dakota, one in Colorado, and one in Idaho. Domestic capacity to produce flakes in the 1959-60 processing season is estimated at 53 million pounds. Flakes are being made commercially in Germany and England; a plant is under construction in Canada and at least one in Australia.

Precooking Heating of Potatoes. Potatoes become very firm and do not slough if they are preheated in water at about 60 to 75° C. for 20 to 40 minutes before they are cooked. The quality of dehydrated mashed potatoes (granules and flakes) can be improved by using this precooking heat treatment. Work at WU has been directed toward determining the effects of this treatment on the physical properties of starch in potatoes, and toward determining its effects on products other than dehydrated mashed potatoes. Isolated potato starch was shown to gelatinize and then retrograde (become less soluble) during the preheating before cooking. A similar loss of solubility was also shown to occur to starch within the intact potato tissue. This loss of solubility is apparently the cause of the reduced stickiness or pastiness of dehydrated mashed potato products given this treatment, and it may be the cause of the greater firmness and reduced sloughing of intact potato tissue that is preheated before cooking. It was also found that if the preheat treatment is used, starch from potatoes produced gels that are firmer than those prepared without preheating.

Consistent with these observations, it was shown that the preheating reduced sloughing in several different products when prepared for use. These included dehydrated potato dice, frozen potato dice, and canned potatoes.

Potato Granules Without Add-back. A process for producing potato granules (dehydrated mashed potatoes) without adding back previously dried granules to the cooked potatoes is being developed at WU. Potatoes are cooked, mashed, dried to about 50% moisture content on a double drum drier, and frozen. The frozen material is mashed and screened, then dried in a cabinet or air lift drier. Sulfite content of about 200 p.p.m. in the finished granule has been effective in controlling processing off-flavor. The sulfite can be applied by dipping the potatoes before cooking; or can be added after cooking during the mashing operation. This product can be reconstituted in boiling liquid without stickiness.

Desirable texture of the reconstituted mashed potatoes results when the proportion of broken potato cells is minimal. Granules having a broken cell count of only 1 to 3 percent, as determined by a new rapid, reliable microscopic method, reconstitute to a desirable product. Cell damage can be controlled to a great extent by avoiding over-drying in the first stage. Occasionally lumpy products have been obtained due to poor granulation. The lumps, which are merely clumps of cells, reconstitute readily and are not evident in the reconstituted product. Bulk density of the final product is usually fairly high, about 0.7 g./ml. High bulk density is desirable to keep packaging and shipping costs low.

The improved microscopic method developed at WURDD for counting ruptured cells in processed potato products shows that stickiness of the reconstituted product increases with the incidence of cell rupturing.

Stickiness is pronounced when 10 percent or more of the cells are ruptured. Progressively lower percentages of ruptured cells are accordingly associated with increased mealiness.

Chips. The chip industry needs a quick, reliable method of estimating the reducing sugar content of potatoes. Some attention was given at EU to the possible application of tablets used for sugar determination in clinical tests. Unfortunately, other substances in potato juice seem to interfere to the extent that this method may not be sensitive enough in the reducing sugar concentration range through which changes in browning tendence are critical, i.e. about 0.2% to 0.4%.

The cooperative research at EU on improvement of the prefrying operations in chip manufacture, conducted under an Informal Memorandum of Understanding with Red Dot Foods, Inc., has been inactive because there is apparently no need for further work. It is planned to terminate this line of study.

The research at Cornell University Agricultural Experiment Station under a contract supervised by EU was completed during the past year with submission of the final report by the Contractor. Nearly all of the findings were given in last year's report to the Committee. Although purified protein fractions did not contribute significantly to browning as do free amino acids, establishment of this fact clarifies thinking in regard to interaction of nitrogen compounds and sugars in chip browning. While chip color is well correlated with reducing sugar content, it is not closely related to non-reducing sugar concentration. By considering both the reducing sugars and sucrose in multiple correlation with chip color, however, a correlation coefficient of near 1 was obtained. (A coefficient of 1 would be perfect correspondence.)

Mechanism of Blistering of Chips. Research at WU has found that blistering of potato chips was reduced if the slices were preheated in water before frying. The treatment required too long a time and there was too much loss of flavor for it to have commercial application. Results indicate, however, that the blister control resulted from extraction of certain metallic ions disrupting the equilibrium between pectin and potassium and calcium and leaving a higher proportion of the pectin bound in relatively firm association with the calcium. Addition of calcium salts to the heating baths greatly enhanced the control over blistering. Blistering was increased by addition of potassium salts to the heating baths, which demonstrated the existence of an equilibrium condition.

Microscopic examination of potato chips has provided conclusive evidence that the cellular structure remains intact and that cell walls rarely, if ever, rupture during the deep fat frying process. Blistering of chips results from simple cell separation due to expansion of steam trapped within the slices when the surfaces become dehydrated and sealed. Deep

fat frying is essentially a cooking and dehydration process during which the starch in the cells is gelled and dehydrated and some of the water in the tissue is replaced with oil. Most of the oil in finished chips is distributed in the cell walls, intercellular spaces and blister areas; apparently much less of the oil present in chips is held between the gelled starch granules within the cells.

Prepeeled Potatoes. By appropriate modification of existing methods for determining sulfur dioxide (SO_2) by iodine titration, a procedure has been developed at EU for determining SO_2 in raw, peeled potatoes. Availability of this simple, rapid method has made it much easier to obtain data on factors influencing the pickup and retention of SO_2. It has been possible to show, for example, that acidified sodium bisulfite dip results in higher SO_2 pickup than does straight bisulfite; that SO_2 uptake increases with increasing concentration of dip; that SO_2 uptake increases regularly with increasing dipping time in the range 1/2 minute to 4 minutes. Prepeeled potato processors should find it convenient to have an easy method available for establishing the SO_2 content of their product. Fixing of the factors regulating the SO_2 pickup will guide processors in their operations.

Plans: In potato flakes, pilot plant research on the process will be continued to adapt flakes to other end uses, as for example in frozen dinners; to further increase flake density for institutional and military use; to build into the product greater tolerance for abuse; and if possible, to further reduce processing costs. Consultation and cooperation will be continued with prospective flake producers and food distributors to further implement industrial production. Engineering and Development Laboratory personnel will continue to assist producers for short periods in starting up plants and in "trouble-shooting" after startup, to the extent that available personnel and funds permit.

In connection with precooking heating, emphasis will be placed on starches that give gels with different physical properties in order to determine why the starches are different. These studies will include size distribution of the starch granules, ratio of amylose to amylopectin in the starches, the degree of branching of the starch fraction, and a measure of molecular size of the starch fractions. Additional studies will be aimed at obtaining a better understanding of the mechanisms involved in the preheat treatment.

The work on potato granules without add-back will be continued.

Additional studies will be made on the causes and control of blistering of potato chips.

Attempts will be continued to streamline analytical determinations aiding in control of production of high quality potato chips.

It is planned to cooperate with processors who try out the rapid SO_2 determination on fresh potatoes to establish its practicability for commercial operations. Attempts will be made to adapt the SO_2 method for use on potato flakes.

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FACTORS AFFECTING PROCESSING CHARACTERISTICS WU

Problem: Determine certain factors related to the processing characteristics of potatoes, with particular reference to suitability of California Long Whites and to establishment of the effect of sprout inhibitors on processing quality.

Program: A continuing program of both basic and applied research being conducted at WU, with support of the Kern County Potato Growers Association and the California Long White Potato Advisory Board, and with the cooperation of the California Agricultural Experiment Station, and with processors, involving one professional Federal man year annually.

Progress: Suitability of California Long Whites. Study of California Long White potatoes has been continued at WU with the support of the Kern County Potato Growers Association and the California Long White Potato Advisory Board.

It was reported earlier that potato granules of good quality can be prepared from potatoes grown in Kern County. The work has been continued on suitability of potatoes from Kern County and nearby areas for production of potato chips and French fries. The results indicate that Long Whites are not very promising for potato chips, but are more promising for French fries. They also indicate that Long Whites tend to develop large amounts of sugars on holding for even a few days, consequently becoming very dark during processing. Wide variations in sugar content and hence in darkening tendency were found between different lots of freshly dug potatoes, and also between different lots of potatoes held at the commonly used storage temperatures of 50 and 60° F. There seemed to be no consistent pattern governing the changes in sugar content that took place under these conditions. "Conditioning" by holding at 70° F. failed to reduce the sugar content to a level that potato chips of satisfactory color could be produced.

Sprout Inhibitors on Suitability. Work is underway at WU to determine conditions for satisfactory distribution of sprout inhibitors, when applied as an aerosol mist that is released into the ventilating air. High air velocities have been found necessary to avoid severe lack of uniformity. This applied work is coordinated with AMS work at Beltsville and with related work at Riverhead, Long Island, New York.

Basic research is also continuing on effects of sprout inhibitors on wound healing. Nearly all published studies on wound healing have been on cleanly sliced potatoes using the entire sliced surface as the wound area. These conditions are not the same as those of punctures, bruises and cuts such as occur naturally in harvest and handling practices. Holding of such potatoes, as for chip manufacture, thus poses problems which may be different from those which have been studied experimentally.

Studies have been undertaken to investigate the natural types of wounding with reference to effects of sprout inhibitors on wound healing, sprouting, and susceptibility to rot microorganisms. Tubers were wounded by nail puncture and penetrating knife cuts, then incubated after dipping in water emulsions of sprout inhibitors at 0.5, 1.0 and 2.0 percent. Some also were inoculated with soft rot organisms before the dip. Preliminary examinations have shown that particularly at the 1.0 and 2.0% level, penetration into the wounded area results in killing internal tissues of the tuber and consequent extensive damage even in the absence of microorganisms. Where limited penetration occurred (0.5%) in the stab-wounds, wound healing was inhibited. These preliminary observations support the thesis that to avoid danger of spoilage, wound healing should be allowed to occur before application of sprout inhibiting treatments since rot organisms can penetrate when wound healing is incomplete.

Plans: The work on processing suitability of potatoes grown in California is being continued with emphasis on effects of cultural and holding conditions in cooperation with the California Agricultural Experiment Station. Effects of processing variables are also being determined.

Work will be continued at a somewhat reduced level on distribution of sprout inhibitors by aerosol application, and on effects of these compounds on wound healing.

DETERIORATION DURING PROCESSING WU, WU

Problem: Determine the causes of and methods of controlling various types of deterioration, such as oxidation, discoloration, and development of off-odor and off-flavor, occurring during processing and storage of potato products.

Program: A continuing program of basic research involving one professional industry-sponsored man-year per year at WU, conducted with the support of the Instant Potato Granule Manufacturers Association, and at a level of less than one man-year annually at EU.

Progress: Oxidative deterioration. Potato granules have been held under a variety of conditions, with and without antioxidants, in cans with oxygen, air and nitrogen atmospheres, and in porous containers. Rapid and accurate methods have been developed at WU for separating and quantitatively determining the residual lipids, or fat-like materials, in the granules. It has been shown that the amount of oxygen absorbed by the product is close to that calculated from the amount of lipid oxidized. The results indicate that the absorption of oxygen is due primarily to oxidation of the lipids, but it has not been determined whether the oxidative flavor and odor result mainly from the lipids, or whether other components are involved. Organoleptic appraisals of flavor and odor are being made to determine whether correlations exist with the quantities of lipids that have been oxidized, as determined chemically. Chemical determinations on carotenoids and phenolic substances are also being made. These substances are easily oxidized. It is interesting that in some cases at least the yellow color of fresh potatoes is related to their content of these latter constituents.

Available resources at EU permitted only limited effort in oxidative studies during the past year. However, experiments have shown that "Tenox IV," containing only butyl hydroxyanisole and butyl hydroxytoluene, is just as effective an antioxidant in potato flakes as "Tenox VI," containing propyl gallate and citric acid in addition to the previously-named components. This is important because "Tenox IV" gives reconstituted mashed potatoes of better color.

After-cooking discoloration. Continued emphasis has been given at EU to the possible roles of polyphenols and other constituents in causing some lots of potatoes to blacken after cooking, particularly at the stem end. While a popular theory holds that this type of discoloration arises from the reaction of polyphenols and iron, previous results failed to show that blackening tissue contained a greater variety or concentration of polyphenols than normal tissue. Experiments showed that only about 25 percent of the iron is "free" and not a part of, or bound to, the potato protein. More free iron, however, was found in the stem end than in the bud end of the tuber.

Potassium deficiency has been thought to be a possible cause of potato discolorations. Potassium determinations were made on extracts from potatoes exhibiting after-cooking discoloration varying from severe to none. Stem-end tissue contained less potassium than did the bud end, although there was no overall correlation between potassium content and blackening degree.

Enzymatic reactions may be involved in after-cooking discoloration at least in an indirect way. Extracts of stem tissue were found to have a higher potency of polyphenol than those of bud tissue. This enzyme system is responsible for the discoloration of raw, peeled potato.

Some investigators have maintained that higher pH at the stem end (lower intensity of acidity) is a key factor in after-cooking discoloration. Limited tests have shown that juice from the stem ends of blackening potatoes usually has a higher pH than juice from the bud ends.

Plans: The investigations will be continued at the present level. In addition to continuing the present lines of research, attempts will be made to develop a chemical method of measuring oxidative deterioration, to aid in developing improved methods for control of the deterioration.

A series of methods has now been developed for determining various constituents that may be involved in after-cooking discoloration. Invitations have been sent to a considerable number of state experiment stations and others to send in samples of blackening potatoes during the 1959-60 storage season so that analytical data may be obtained on potatoes of different variety and grown in different locations.

III. MARKETING RESEARCH

A. Market Potentials, Preferences, and Development

MARKET POTENTIALS FOR NEW AND IMPROVED POTATO PRODUCTS MD

Problem: Assist in expanding markets for potatoes by evaluating the commercial feasibility of new or improved forms of potatoes and appraising the impact of such products on the present market for potatoes so as to assist in the further commercial development of these products by producer and processor groups.

Program: The program is one of product and market testing research and economic analysis, for the most part conducted in collaboration with the four regional laboratories of Agricultural Research. The continuity of the program is dependent on new product developments of the utilization laboratories. Field studies are national, regional, or local, depending on the nature of the particular problem being researched. Less than one professional Federal man-year annually is involved in this work at the present time.

Progress: Exploratory work is under way to determine the feasibility of conducting a full-scale study on the market expansion possibilities for different forms of processed potatoes in selected outlets. A full-scale study will provide information on the degree and kind of competition between various forms of potato products in various end-uses as well as the penetration of each of these end-use markets by various forms of processed potato products. This information is needed by producer and other groups interested in entering the manufacture of processed potato products.

Plans: Exploratory work will be continued with particular emphasis on distributors, retailers, and end-users such as restaurants, hotels, etc., of processed potato products in one or two large metropolitan areas. Before any full-scale study is undertaken, determination will be made to see if the data available from the above sources can assist in providing the kind of information needed to answer questions on the potential for processed potato products.

B. Measurement and Evaluation of Market Quality

OBJECTIVE MEASUREMENT OF MARKET QUALITY FACTORS MQ

Problem: New and improved methods and techniques of identifying and measuring quality factors in potatoes are needed to provide better inspection, grading, and standardization of this commodity.

Program: This program of applied and basic research is conducted at Beltsville, Md., and involves less than one professional Federal man-year annually.

Progress: Research continued on developing a method of nondestructively detecting hollow heart in potatoes by light transmission. This investigation indicated that the discolored tissue exhibited a selective absorption of energy. A measurement of the optical density difference between wavelengths of 800 mu and 710 mu was used as an indication of discoloration. The method detected the presence of hollow heart 98 percent of the time in a sample of Irish Cobbler potatoes containing 61 percent hollow heart. In a test with Katahdin potatoes, 81 percent of all discolored tubers were detected, including potatoes with decay, greening, blackspot, and hollow heart.

Plans: No definite research plans have been formulated at this time.

C. Product Protection During Marketing

POSTHARVEST PHYSIOLOGY AND STORAGE MQ, CR

Problem: There is need to develop improved methods of handling and storage of potatoes for the prevention of bruising, sprouting, and other wastage so as to insure potatoes of suitable quality for the various specialized uses to be made of them.

Program: This continuing long-term program of basic and applied research is conducted in cooperation with the Transportation and Facilities Research Division, the Red River Valley Potato Grower's Association, and the Minnesota, North Dakota, and Maine Experiment Stations. The work is conducted in the Red River Valley, Maine, and Beltsville, Maryland, and involves about two professional Federal man-years annually, plus a contract with the Medical College of Virginia, Richmond, to study the toxicity of CIPC.

Progress: Control of sprouting with CIPC. Treatments to inhibit sprouting showed better sprout inhibition when the vaporized chemical was distributed by air circulation than when allowed to diffuse naturally. It was necessary for the CIPC vapor to reach the eye of the potato to be effective. Treatment with either a solution containing 1000 ppm CIPC or a dust at the rate of 0.1g CIPC per bushel of potatoes partially controlled sprouting in potatoes stored at 55° F. Complete sprout control was obtained with a 2500 ppm CIPC suspension dip, or a CIPC dust at the rate of 0.25g CIPC per bushel of potatoes.

Suberin and periderm developed on slices of potato tissue treated with solutions containing less than 25 ppm CIPC. At concentrations of 50 ppm and above periderm development was almost completely inhibited. Some inhibition of suberin development was noted in slices treated with solutions containing 1250 ppm. Slices of potatoes dipped in CIPC solutions or suspensions and held for 14 days before inoculation with Erwinia carotovora developed decay regularly only in slices treated with solutions containing at least 1250 ppm CIPC.

Control of sprouting with alcohols. Numerous growth or sprout inhibitors have been tested in Crops Research, including several long-carbon chain alcohols. Vapors of nonyl alcohol supplied continuously, effectively suppressed the sprouting of Katahdin potatoes. Removal of the alcohol vapors resulted in the growth of new sprouts after several weeks indicating that this treatment might be useful for improving the storage quality of seed potatoes.

Potatoes treated by Market Quality for 20 minutes with vaporized nonyl alcohol showed no sprout control after several months of storage at 55° F. Some sprout inhibition was obtained for several weeks when potatoes were exposed to vapors of nonyl, decyl, hexyl, or iso-octyl alcohol for seven days and then stored at 55° F.

Foliar application of maleic hydrazide. Studies were continued in the Red River Valley to extend the storage period of late-crop chipping potatoes by treatment with a foliar application of maleic hydrazide and storage at 50° to 60° F. The study involved 80 one-ton boxes of Irish Cobbler and Kennebec potatoes. Color of chips from all lots was satisfactory and remained essentially unchanged from harvest until the end of the holding period. In general chips made from Kennebec were lighter in color than those made from Irish Cobbler potatoes. Untreated lots could not be held beyond February 16 because of excessive weight loss from sprouting, whereas those treated with maleic hydrazide were held to April 15 when the weight loss averaged over 10 percent. Shrinkage studies indicated a relation of box height and vapor pressure deficit to losses, but were inadequate to establish a direct relation.

Maleic hydrazide treatment of potato plants in the field has been reported to make the treated potatoes more difficult to recondition for chipping. Tests with three varieties from Maine showed no difference between MH treated and untreated lots in their reconditioning response shortly after harvest or after 1, 2, 3, or 4 months' storage at 32, 40, 50, or 60° F. All lots reconditioned much more readily after storage for a few months than shortly after harvest.

Toxicity studies with CIPC. The Medical College of Virginia has completed the actual feeding portion of their experiments to determine the toxicity of isopropyl N-(3-chlorophenyl) carbamate (CIPC). Survival and growth rates during the two-year rat and one-year dog feeding tests indicate that the toxicity of CIPC is low enough to permit sufficiently high tolerances to be established for its use as a sprout inhibitor. Histopathological studies of the sacrificed animals which are needed for a final evaluation of the toxicity of the compound are almost completed.

Chip color as related to CO_2 in tuber tissues. Previous studies showed that potatoes grown in wet soil had a high CO_2 content and produced dark-colored chips. Treatment of tubers at 60° F. with 30 and 90 percent CO_2 for 3 to 9 days increased CO_2 content of the tubers, conductivity of leachate from thin slices, and respiration rate of whole tubers. These changes were associated with dark color of chips made from treated tubers.

Storage and chipping quality of new varieties. Of the 15 varieties harvested at two different dates in the Red River Valley only Cherokee, Irish Cobbler, Nordak, Norgleam, and Norland made satisfactorily colored chips at both harvest dates. In addition, Dazoc from the early harvest and Russet Burbank from the late harvest made satisfactory chips. After about four months' storage at 50° to 60° F., Cherokee, Dazoc, Irish Dobbler, and Kennebec from both harvests, and Plymouth from the late harvest, processed into chips of satisfactory color. Following storage at 40° F. for several months and reconditioning at 80° for three weeks, only Dazoc and Irish Cobbler produced chips of acceptable color. However, Kennebec, Plymouth, Russet Burbank, and Tawa closely approached the level of acceptability. Norland had the shortest and Russet Burbank the longest dormant period at 50° to 60° F. Norland's dormant period was about two weeks shorter and Russet Burbank's about two weeks longer than such varieties as Irish Cobbler, Kennebec, and Red Pontiac.

Handling and storage practices in Red River Valley. The 40-foot trough-belt conveyor developed by the Transportation and Facilities Research Division for filling below ground storage bins resulted in substantially less bruising than the conventional method.

Studies conducted in cooperation with the Transportation and Facilities Division on the storage of commercial size lots of washed (but not dried) potatoes were expanded to include two bulk bins with through circulation and one with shell air circulation. These were compared with unwashed potatoes in a bin with shell circulation. No difference was found between the washed lots and the unwashed in percent U. S. No. 1 grade, weight loss, or decay. However, over one-half of the washed potatoes had slightly sunken lenticels whereas only one percent of the unwashed potatoes were thus affected. While these sunken lenticels did not affect the grade of the potatoes, they would probably reduce their market value. There was considerably less Rhizoctonia sclerotia on the potatoes washed as they went into storage than those washed as they were removed from storage. The general conclusions were that there is not enough advantage in washing and grading into storage to pay for the extra cost.

Handling and storage practices in Maine. Repetition of last year's experiments on the effect of different air flow rates on late blight, frozen tubers, stone bruises and shatter bruises again showed that air flow of one cfm per barrel per minute produced the greatest percentage of marketable tubers.

Tests of modified atmosphere storage for late market potatoes were initiated. After a six-week storage period at 55 to 60° F., there was less sprouting in an atmosphere containing 10 percent CO_2 and 10 percent O_2 than in checks maintained in a normal atmosphere. No internal tuber discoloration was noted.

Studies were initiated on prestorage washing of pallet bin lots of tubers. All fall washed potatoes had a high incidence of lenticel infection regardless of the method of drying after washing. The incidence of silver scurf

and Rhizocotonia was about the same in the washed and unwashed lots. Weight loss was slightly greater in washed tubers than in the unwashed lot, but there was little or no difference in the percent of marketable potatoes. Winter washed potatoes appeared brighter than potatoes washed in the fall.

Plans: Further work is planned on postharvest sprout inhibitors with emphasis on methods and timing of application. The studies with preharvest application of maleic hydrazide are completed. The CIPC toxicity study is complete except for preparation of the final report. No additional work is planned on chip color as related to CO_2 concentration in tuber tissues. The varietal tests for adaptability for chip manufacture will continue for another season. Studies of quality as related to bin loading equipment are completed, but work will continue on the effects of air volume in storage. Work in the Red River Valley on washing of tubers prior to storage is completed, but further studies are planned in Maine using pallet bins.

POSTHARVEST DISEASES MQ

Problem: Better methods of control are needed for physiological and pathological disorders of potatoes which result in unsatisfactory quality or excessive wastage during storage, transit, and marketing.

Program: A continuing long-term program involving basic studies on the nature of temperature induced pathological changes in potatoes and applied research on the control of both physiological and pathological disorders with studies conducted at field laboratories in Maine, Minnesota, and California, at market laboratories in Chicago and New York City and at Beltsville, and involves about one professional Federal man-year annually.

Progress: Factors affecting incidence of internal black spot in Maine. Internal black spot was noted in mid-February in potatoes stored in commercial bins with some samples showing six percent internal discoloration. A series of samples receiving various cultural treatments including fertilization, maturity at harvest, and vine killing methods were subjected to 500, 250, and 125 pounds of pressure per square foot and placed in controlled temperature rooms of 38, 45, and 50°. The incidence of internal black spot in all samples after six to seven months' storage was very low with the highest incidence (8 percent) occurring at the 38° temperature in the potatoes subjected to the greatest pressure. Differences in the incidence of internal black spot in the various samples were not significant. Histological studies of tubers with internal black spot indicated a concentration of starch in the affected area.

Beltsville internal black spot tests. Katahdin potatoes bruised at harvest or after one and two months of storage at 35°, 50 and 55° F. while the tubers still remained firm (turgid) did not develop internal black spot. After two months of storage, tubers from 35° showed shatter bruises after heavy impact loads whereas the tubers from 55° showed no effect. After six months of storage the less turgid shrivelled potatoes from the open

containers at 55° developed internal black spot in about 50 percent of the bruised tubers after bruising. The firm (turgid) potatoes stored at 55° in polyethylene bags, as well as the samples at 35° and 40°, did not develop black spot after bruising.

Tow methods of measuring firmness (1) the Durometer (types 00 and A-2) and (2) the Cornell pressure tester were compared with the resonant frequency method of measuring potato tissue turgor. Of the three methods, the Durometer was the most convenient and, while unsuitable for the firm tubers, gave readings about as meaningful as the other two methods.

Long Island grown Green Mountain tubers developed no symptoms of this disease when bruised shortly after harvest. After six months' storage at 55° F. the tubers were severely shrivelled. Gentle shaking of these tubers resulted in rapid development of black discoloration under the skin and one-fourth to one-half inch into the flesh in a major portion of the tuber. Approximately 95 percent of the shaken tubers developed symptoms whether they were subsequently held at 55° or 75° whereas nonshaken tubers developed almost no internal discoloration.

Irish Cobbler tubers were stored six months in commercial storage and three months at 36° F., then bruised and transferred to 75°. Though still turgid at time of bruising, approximately 70 percent of the tubers developed internal black spot within 24 hours.

Tubers of four varieties were stored seven months at 40° F., and then held in open containers or polyethylene covered containers at 75° for a month. Only a trace of internal black spot developed on any of the varieties bruised immediately on removal from 40° while all tubers were still firm. After a month at 75° tubers in open containers were severely shrivelled and 24 hours after bruising Sebago, Pungo, Kennebec, and Plymouth had 80, 100, 73, and 91 percent internal black spot, respectively. Tubers covered with polyethylene during the 75° holding were mostly firm and 24 hours after bruising had 0, 40, 0, and 33 percent internal black spot.

Plans: Studies in Maine and at Beltsville will be continued with emphasis on the effect of various cultural practices and storage environments on incidence of black spot. California studies on black spot will be initiated if there is some indication of susceptibility to the disorder in the 1960 crop. These studies will stress the effects of handling and transit practices and tuber maturity. In addition, an attempt will be made to develop a method of forecasting susceptibility.

MAINTAINING QUALITY DURING TRANSIT MQ

Problem: With the adoption of new types of rail and truck equipment and the use of heavier loads and faster rail schedules, there is need for study of methods of loading and protective services under these changing conditions for the varied needs of potatoes for chips, seed, and table use during the seasonal extremes of winter and summer shipping periods.

Program: A continuing program involving studies on icing and ventilation services, heater placement, load heights and load patterns, and on evaluating new and improved truck and rail equipment for obtaining desirable transit temperatures and protection from bruising or other damage in transit. Different aspects of this broad study are under way at the Fresno, California; East Grand Forks, Minnesota; Orlando, Florida; Miami, Florida; and Presque Isle, Maine field laboratories, in cooperation with Transportation and Facilities Research Division, potato shippers and receivers, and the railroad and trucking industry, and involves about two professional Federal man-years annually.

Progress: Winter Protection of chipping potatoes from the Red River Valley. Twenty-four semi-trailer truck shipments of chipping potatoes were studied to determine the value of floor racks and forced air circulation in improving transit potato temperatures. When there was no forced air circulation, bottom layer temperatures were low. Forced air circulation, particularly when floor racks were used, resulted in very good transit temperatures. Floor racks were no better than straw on the floor when there was no forced air circulation. Air temperatures at the trailer floor indicated the need of a windproof canvas loading tunnel and the value of maintaining forced air circulation during loading.

Shipment of precut seed from Maine. Five refrigerator car test shipments, each with 50,000 pounds of precut potatoes, were made in 1959. Two alcohol heaters (13,000 B.t.u./hr.) were installed in each car, with thermostat settings of 55° or 60° F. With either setting, tuber temperatures reached approximately 50° in 24 hours and 55° to 60° in 48 hours. Even though heaters were extinguished after 24 to 48 hours, heat of respiration of the tubers was sufficient to maintain temperatures above 60° during the remaining three to four days of transit. Tuber temperatures usually were approximately 75° on arrival. Decay was serious in the first car in which tuber temperatures varied from 80° to 88° at destination.

Planting tests of precut seed. Seed pieces from one shipment were stored at 40, 45, 50, 55, and 60° F for six weeks before planting. Sprouting was heavy at 50° and above. A trace of decay developed at 40 and 45°; 20 percent mostly slightly decay developed at 50°; and 45 and 59 percent moderate to severe decay developed on seed pieces at 55° or 60°, respectively. Healthy seed pieces from these storage conditions were planted and emergence time and stand compared with fresh cut potatoes, "B" size, and precut seed planted 24 hours after arrival. No difference in emergence time or stand was discernible.

Planting tests with seed cut and stored at Beltsville. Seed pieces of Plymouth, Sebago, Pungo, and Kennebec were cut and stored ten days, or 2-1/2, 3-1/2, 4-1/2, and 5-1/2 months before planting in North Carolina and Delaware. Little or no decay developed on seed pieces of any varieties cut ten days before planting.

When decay developed on seed pieces stored for longer periods, it usually was more severe on seed pieces stored at 50° F. than on those stored at 40°. Less decay developed on seed pieces cured one week at 60° before storage at

40° or 50° than on those stored immediately at 40° or 50°. Plymouth seed pieces had more severe decay than any of the other varieties. Kennebec seed pieces had the least amount of decay.

When planted in North Carolina, freshly cut seed pieces and whole "B" size potatoes of Plymouth and Sebago had higher stands and yields than most of the precut seed piece treatments. No consistent effect of time of cutting or storage temperature on stands and yields of either variety was apparent. Yield of several of the precut treatments of Pungo were slightly higher in Delaware than the fresh cut or "B" size, the highest yield being from those seed pieces cut 3-1/2 months before planting and held at 60° F. one week before storing at 50°.

Holding precut seed in Maine. Precut seed potatoes containing known amounts of freeze injury and blight were stored at 70° F. for seven days. Potatoes which were sound when stored, showed a slight amount of soft rot after storage. Samples containing 2 percent frost injury had about seven times as much decay. Those containing 5 percent frost injury had about 16 times as much decay. Samples containing late blight infected tubers varied widely in amount of decay as the blight infected tubers had in many instances dried out.

Samples containing four percent late blight and frosted tubers were treated with two formulations of Captan, a 7-1/2 percent dust and a 50 percent wettable powder, and Agrimycin 100. One series of samples was held at 70° F. and two series were shipped to Springfield, Massachusetts, in a car of precut seed. No significant differences in seed piece decay were found between treated and untreated lots.

Protective services for chipping potatoes from California. Potatoes shipped from California by rail to chip manufacturers in the midwest should be maintained in transit at temperatures between 60 and 70° F. to provide optimum chip quality. Temperatures in this range were obtained in a car that was pre-iced to half-stage capacity and had one ton of ice remaining in each bunker at loading with potatoes with 80-83° pulp temperatures. The car was shipped with vents closed until it was re-iced on the third day in transit after which the vents were left open. Potatoes with 79° pulp temperature shipped in a dry car, initially iced after loading with 2 tons of ice in each bunker, with vents open, ccoled excessively in the bottom layer before the ice was melted. This showed the danger of over-icing during periods when train movement and consequent air circulation was relatively slow. Standard ventilation failed to prevent potato temperatures in the top layer of the load from dropping below 60° during cool nights. Chip color was darker in potatoes that were cooled below 60° than in those hold above this temperature. The potatoes shipped in these cars were not washed and developed must less decay in transit than the washed tubers shipped in previous tests. Washing causes high relative humidity, particularly in cars with vents closed and this apparently favors decay at transit temperatures above 60° F.

Loading methods on bruising in heavy loads. Much of the bruising observed in California potatoes on arrival at the market has been attributed to the "Bump" method of loading the cars with hand trucks. Tests comparing hand stacked and "bumped" loads showed no consistent effect of method of loading on transit bruising in heavy loads of 430 one-hundred-pound burlap bags.

Load size on quality of Florida potatoes. These studies were made to determine if the heavy loads used as a result of incentive rates increased bruising, decay, or temperature of the potatoes. The potatoes were packaged in 100-pound burlap bags and shipped in refrigerator cars from Florida to northern cities for chip manufacture. The results showed that weight of load had little effect on bruising. For example, slight bruising averaged 2.9, 3.3, and 3.6 percent, respectively, in loads of 360, 400, and 500 100-pound burlap bags per car. Moderate bruising amounted to 0.7 in all loads. A slight trend was observed in the amounts of severe injury. The average severe damage amounted to 3.9 percent in the 360 100-pound bag load, 4.2 percent in the 400-bag load, and 4.7 percent in the 500-bag load. In one series of tests there was slightly more lenticel infection in the heavier than the lighter loads. No significant decay occurred in any of the other tests. During the transit periods the outside air temperatures frequently exceeded 95° F.; however, commodity temperatures all averaged about 60° at destination and were not measurably affected by size of the load.

Plans: Studies on the winter protection of chipping potatoes from the Red River Valley will be extended to include rail tests with new mechanical and other thermostatically controlled equipment. Shipping tests with precut seed potatoes will be continued, particularly to determine the lower temperature limits at which adequate suberization can be obtained. Additional shipping tests will be conducted to determine the best hot weather protective services for California chipping potatoes and tests will also be conducted on the protection of table stock shipped in late June and early July. Studies on heavy loads of potatoes for chip manufacture from Florida have been completed.

Publications: Healing Precut Potato Seed Pieces During Transit. H. W. Hruschka, W. L. Smith, Jr., H. V. Toko, and R. V. Akeley, AMS Rept. 334. 1959.

D. Transportation, Storage, and Packing

IMPROVED CONSUMER PACKAGES, SHIPPING CONTAINERS, AND METHODS OF PACKAGING TF

Problem: Develop new and improved consumer packages, master containers, and bulk shipping containers which will better protect potatoes from damage, improve their salability, reduce marketing costs, and improve trade and consumer acceptance.

Program: A continuing several year program involving field testing of new packages and containers and methods of packaging potatoes at the Fresno, California, and Orlando, Florida field offices, in cooperation with manufacturers of packages and containers, the Kern County Potato Association, and various growers, shippers, and distributors of potatoes in California, Florida, and Alabama, and involving about one Federal man-year annually.

Progress: Consumer packaging of California Long White potatoes. Ten controlled rail test shipments were made during the 1959 season in which California Long White potatoes were prepackaged in 10-pound poly bags and 10-pound multiwall paper mesh window bags. The 10-pound poly bags were packed in 50-pound multiwall Kraft paper baler bags. The 10-pound paper mesh window bags were packed loose without a master container. Cost of packaging materials per 10,000 pounds of potatoes or 1,000 bags were as follows:

Poly bags (1 mil printed)	$24.40	
Wire ties for closing	.52	
200 baler bags and wire ties for closing	16.80	
Total per 1,000 bags		$41.72
Paper mesh window bags	37.70	
Cotton twine for closing	.30	
Floorboard padding material	.90	
Total 1,000 10-pound paper bags		$38.90

The cost of packaging materials for prepackaging potatoes in poly bags and packing them in paper master containers was about three-tenths of a cent higher per 10-pound bag than for packaging them in paper mesh window bags. Savings in loading, unloading, and handling the poly bags packed in master containers as compared to paper mesh bags handled individually have not yet been ascertained.

The potatoes packed in poly bags usually lost about an ounce, whereas those packed in paper mesh window bags lost seven to eight ounces. The higher humidity in poly bags helps to prevent potatoes from darkening or discoloring where they have been skinned. In the paper bags, 34 percent of potatoes were skinned and discolored as compared to three percent for potatoes packed in poly bags. Also, 19 percent of potatoes packed in paper bags were skinned and not discolored, as compared to 33 percent skinned and not discolored in poly bags. Bruising averaged only .4 percent in paper bags and .6 percent in poly bags.

There was no difference found in the amount of greening in either type of bag. Decay also was identical, averaging .1 percent in both types of bags. However, previous studies indicated if there is decay or breakdown present, it develops much faster in poly bags than in paper mesh window bags.

Four of the controlled test shipments contained potatoes which had been dried by hot air blasts before packaging and the remaining four test shipments were packed while the potatoes were still moist--the standard practice.

Whether they were packed dry or wet made no difference for potatoes packaged in poly bags, although there was more discoloration found in the dried potatoes packed in the paper mesh window bags than in the wet potatoes packed in paper mesh window bags.

Trade acceptance of potatoes packed in poly bags was very good; the chief reservation being greater possibility of breakdown if decay is present and increased likelihood of greening while on display in retail stores if not properly rotated.

Shipping containers. No additional test shipments of potatoes packed in new types of shipping containers were made during the 1959 season. Fiberboard boxes were used commercially for shipping Long White California potatoes in 1959, in spite of their considerably higher cost, 58 cents for two 50-pound fiberboard boxes as compared to 19 cents for 100-pound burlap bags. The problem of offering and packaging potatoes in various containers in the same packingshed is still troublesome. Studies made during the 1959 season in California, show that it took .71 man-minutes to pack 100 pounds of potatoes in burlap bags as compared to 1.76 man-minutes to pack 100 pounds in two 50-pound fiberboard boxes, and 4.5 man-minutes to pack 100 pounds of potatoes in ten 10-pound paper mesh window bags.

Plans: It is planned to continue to evaluate the possibility of prepackaging potatoes at point of production, particularly the early varieties, such as California Long White and round Red potatoes in poly and paper mesh window bags. It is planned to extend these studies to Florida and Alabama during the spring of 1960 to see if they can be economically prepackaged at point of shipment and if the quality can be maintained through their normal marketing channels. It is planned to hydrocool the Alabama potatoes prior to packaging.

Publications. Idaho Fresh Fruit and Vegetable Prepackaging. Donald R. Stokes, Idaho Grower Shippers Association, Inc., Yearbook, 1959:35, June 1959.

Fresh Produce Prepackaging Practices in the United States, Marketing Research Rept. No. 341, Thomas B. Smith and Juan Jose Valldejuli, USDA, July 1959.

The Next Ten Years of Produce Packaging. Donald R. Stokes, presented at the annual Convention of the Produce Packaging Assoc., at Philadelphia, Pa., Sept. 16, 1959 (USDA mimeo).

BETTER LOADING METHODS FOR RAIL AND TRUCK SHIPMENTS TF, MQ

Problem: Many growers, shippers, and receivers of potatoes have been experiencing considerable losses from mechanical damage, including bruising, and from overheating and spoilage in shipments of potatoes by rail and truck because of heavier loads and lack of adequate circulation of air. Improved loading patterns which permit the air to flow freely around the bags can be effectively used without any additional costs by shippers, truckers, and receivers to provide better protection and to reduce spoilage and overheating losses during transportation.

Program: This long-term program of research to develop better loading methods and related equipment to prevent mechanical damage to the bags and potatoes and preserve and protect product quality during transportation is conducted with rail and truck shipping tests from various producing areas to many terminal markets, is carried out in cooperation with MQ,growers, shippers, receivers, truckers, and railroads, and requires about one professional Federal man-year annually.

Progress: Loading methods for trucks. Limited work begun with shipments from Florida in the spring of 1959 and continued with shipments of New Jersey potatoes to the South late in the summer resulted in the development of a new "air flow" pattern for truck shipments. With this method the air entering the front vents of the trailer is not permitted to bypass the load but is forced downward and through its entire length, thereby providing air movement around almost every bag in the load. Preliminary test results indicate sufficient air velocity through load to insure removal of product heat, favorable temperatures upon arrival of long-distance shipments in hot weather, little or no load disarrangement or product damage, and no greater labor or material costs for the new loading pattern.

Heavier loading of rail shipments. Test shipments with Florida potatoes to Northern markets to determine the effect of substantially heavier loading under the carriers' incentive rate program on air movement showed that there was little or no air movement through or over the load in cars shipped under ventilation. A new loading pattern and method of manipulating ventilation openings in the bunker bulkheads by which the air flow can be forced through the load was developed, but the shipping season ended before any tests could be made with it.

Plans: Shipping tests with the new "air flow" loading pattern for truck shipments will be continued with shipments from New Jersey, Long Island in the fall and Florida in the spring. In the spring of 1960 a series of test shipments to measure the effectiveness of the new "air stack" pattern for rail shipments will be made from Florida. Preparation of an interim report on this research will be begun during the next year.

E. Equipment, Facilities, Methods, and Firm Efficiency

IMPROVED METHODS, EQUIPMENT, AND FACILITIES FOR STORAGE TF, MQ

Problem: Develop more efficient work methods, techniques, devices, equipment, and design improved facilities for handling, storage, and preparation for market of potatoes at concentration and shipping points.

Program: A long-term program involving engineering-economic research on development of improved handling, storing, and packing methods, techniques, equipment, and facilities carried on by field offices located at the Red River Valley Potato Research Center, East Grand Forks, Minnesota; the Maine Potato Handling Research Center, Presque Isle, Maine; Long Island Vegetable Research Farm, Riverhead, New York; and Gainesville, Florida; in both laboratory and commercially-owned facilities in North Dakota, Minnesota, Maine, New York, Florida, and Alabama; in cooperation with the North Dakota, Minnesota, Maine, New York, New Jersey, and Florida Agricultural Experiment Stations, the Red River Valley Potato Growers' Association; the Market Quality Research Division and the Marketing Economics Research Division of AMS; and the Harvesting and Farm Processing Branch, Agricultural Engineering Research Division of ARS; at a current rate of about five professional Federal man-years annually.

Progress: Handling, storing, and packing the midwestern fall crop. At the Red River Valley Potato Research center, the manuscripts "Ventilating Potato Storages in the Late Crop Area," "Methods and Equipment for Handling Potatoes into Storage in the Red River Valley," and "Potato Pressures and Bin Partitions" were revised by the authors. Two additional manuscripts for Department publications entitled, "A Light-Weight Conveyor for Filling Deep Bin Potato Storages" and "Pallet Boxes for Potatoes" were completed during the year.

An overhead-track-supported, 40-foot trough-belt conveyor, developed at the Red River Valley Potato Research Center, was modified on the basis of earlier tests and further tested during the 1958 harvest season. These tests confirmed previous results that this method of filling deep bins injures fewer potatoes during bin filling than other methods so far developed. However, this equipment deposits the potatoes under the ceiling track in a wedge shape, concentrates the dirt and segregates potatoes by size as they roll down. This results in unevenness in packing operations. A traveling crane conveyor support has been developed and installed which should eliminate these difficulties by distributing the potatoes better.

Studies were made to determine comparative labor and equipment costs of moving potatoes from the storage to the packing lines. The data cover methods of moving potatoes by flume and conveyor and hand forking in bulk and by forklift truck in pallet boxes.

Past research has indicated two to three percent major injury as potatoes flow from the packing lines and drop at least 30 inches in starting to fill 100-pound burlap sacks. A spring clip was developed which holds the bottom

of these sacks until they are about half full at which time the weight of the potatoes releases the sack from the clip, allowing the potatoes in the lower part of the sack to fall en masse after which filling is completed.

An exploratory cost analysis of the labor, equipment, materials, freight, and injury losses which occur during packing, loading, transport, and processor handling and temporary storage of potatoes was made to compare the use of 100-pound burlap sacks and one-ton capacity collapsible pallet boxes which were returned for reloading. The analysis indicates pallet box shipping has the advantage for certain distances.

Further consultation and checks were made of the newly designed storages featuring envelope-type circulation. For arid climate, studies indicate that this type of storage has a considerable effect on reducing shrinkage losses. Two plants using this ventilation method have been constructed.

Assistance on equipment, handling, and storage problems was provided to approximately 300 firms and individuals by project personnel at the Center.

Handling, storing, and packing the eastern fall crop. At the Maine Potato Handling Research Center, an industrial engineer, appointed in May 1959, devoted his time to an orientation period, search of literature on potato handling and storage, and review of data collected by previously assigned personnel and others cooperating with the Department. A summary and evaluation has been made of this data for the preparation of a manuscript on handling potatoes from storage to the packing line.

A manuscript on "Mechanized Methods of Receiving Potatoes at Trackside Storages" is currently being cleared for publication as an Experiment Station Bulletin.

Storing the northeastern late summer crop. Major effort was placed on preparation and editing the manuscript "Storage of Fall Harvested Potatoes in the Northeasten Late Summer Crop Area," to be published as a Marketing Research Report. If procedures and policies recommended in this report are followed, a producer on Long Island having a 12,000 hundredweight crop could expect to increase his annual return about $2,600.

Although AMS cooperation was terminated January 31, 1959, the Cornell University Agricultural Experiment Station is continuing some work in this area with their own personnel. Prior to January 31, 1959, in addition to the applied storage investigations, a more basic study involving a statistical analysis of seven years of Long Island weather and the development of a procedure for determining the expected theoretical dry bulb storage temperature and the moisture deficiency in the ventilating air during cooling was conducted. Frequency distributions of dry bulb temperature and relative humidity and empirical probabilities of selected intervals of dry bulb temperature and relative humidity occurrences during each month in the initial cooling period were developed. The manuscript "Comparative Methods of Cooling Long Island Potato Storages" was revised.

Handling and packing the southeastern spring crop. Effective July 1, 1959, an industrial engineer was assigned to this work and located at Gainesville, Florida, field office. Layout drawings and process charts were developed for three potato packinghouses located in the Hastings, Florida, area. Detailed information concerning equipment items used in these plants was obtained. A description was written covering representative methods of receiving potatoes at the packinghouse in the Hastings area. Information from preliminary time study work on receiving operations was summarized. Progress was made toward conducting cooperative work with the Agricultural Engineering Department of the Florida Station.

Plans: At the Red River Valley Potato Research Center, storage studies of potatoes in pallet boxes will be made to relate shrinkage to box height, vapor pressure deficit, and time.

The traveling crane conveyor support will be tested with the 1959 crop to give better distribution of dirt and potatoes during filling storage bins.

Data developed on labor and equipment costs for moving potatoes from bin to packing line will be analyzed to compare labor and equipment costs for various types of storages using flumes, conveyor and hand forking for bulk potatoes and forklift truck handling of potatoes in pallet boxes. A report on this work will be prepared and submitted for publication.

Tests will be made of the spring clip, for filling 100-pound sacks to determine its effectiveness.

Following an exploratory analysis, a field study and more complete cost analysis will be made of the relative advantages of shipping potatoes to processors in 100-pound bags and in pallet boxes.

A high-speed potato sizer will be designed and built for separating potatoes in three or four sizes before storage.

A check will be made to determine the feasibility of using polyethylene membranes to separate small lots of potatoes in large deep bulk bins.

At the Maine Potato Handling Research Center, additional data will be obtained to supplement the studies already made for handling potatoes from storage to the packing line. This will include methods not previously studied and additional information needed to amplify the results of the former studies. A manuscript covering these studies will be prepared during 1960.

Work sampling studies will be made of the over-all packing line with selection of lines to include representative operating methods and output rates.

Work in connection with late summer crop potatoes will be devoted to editing and publication of the two manuscripts mentioned above, "Storage of Fall Harvested Potatoes in the Northeastern Late Summer Crop Area" and

"Comparative Methods of Cooling Long Island Potato Storages." Two separate but related papers presenting the work accomplished on the weather data study will be prepared.

In the spring crop area, efforts will be directed toward developing more efficient and satisfactory methods for handling the potatoes from the field to the packing line. The dumping of potatoes from a dump-type truck body onto a floor will be tested. If found practicable, further checks will be made to determine the advantages of faster unloading, more economical plant facilities for receiving and temporary holding of potatoes, and less specialized type of truck for bulk handling of potatoes. Existing receiving and holding methods, primarily covering bulk handling, will be studied and compared for the purpose of informing industry regarding the relative efficiency of each. Equipment and methods for filling, weighing, and closing 50- and 100-pound burlap bags will be investigated. The sorting operation also will be studied and attention will be given to a better means of removing vines and trash from flumes.

F. Costs, Margins, and Organization of the Marketing System

CHANGES IN METHODS OF MARKETING POTATOES ME

Problem: Potato industry leaders need more accurate information on the changes taking place in wholesale markets for fruits and vegetables in order to evaluate the impacts of these changes on the potato industry and to assist in making decisions and recommendations for adjustments to meet these changes.

Program: A three-to four-year research program involving approximately four professional Federal man-years annually, contracts with the University of California, Berkeley, California, and Midwest Research Institute, Kansas City, Missouri, for field work in two markets, and in cooperation with the Agricultural Experiment Station in Wisconsin, West Virginia, Oregon, Kentucky, Maine, Montana, New York, Utah, and Oklahoma.

Progress: Sharp increases have occurred in direct buying by retailer groups--both corporate and voluntary chains--and, to some extent, by service wholesalers and other types of wholesale handlers. The number of retailing groups large enough to take advantage of direct buying has grown until they now handle a major portion of the retail food business.

Fieldwork is now underway for a study of the present status and organization of approximately 20 wholesale fruit and vegetable markets throughout the country. The impacts of changes in market structure on producers, shipping point marketing firms and wholesale marketing agencies will be evaluated in this study in order to provide information as a basis for adjustments by these firms which will be needed by them to compete successfully under the changed conditions.

Plans: Study will continue with cooperation from State Agricultural Experiment Stations in West Virginia, Texas, Wisconsin, Oregon, Montana, New York, Maine, Oklahoma, and Kentucky.

Publications. The Changing Role of the Fruit Auctions Auctions. Alden C. Manchester, USDA, MRR 331, June 1959.

EVALUATION OF THE PROCESSING MARKET FOR POTATOES ME

Problem: The rapid growth of the processing market for potatoes is causing many adjustment problems for producers and fresh market distributors, as well as processors. This study will provide insights into these problems to assist producers and marketing firms in making these adjustments.

Program: This is a three-year cooperative research project with the Idaho Agricultural Experiment Station using between one and two man-years per year of Federal professional labor.

Progress: The current phase of this project deals with input--output relationships in potato processing plants. The yield of frozen French fries from 100 pounds of raw unpeeled potatoes ranged from 32 to 45 pounds (averaging 38 pounds). Processing costs for frozen French fries ranged from 4.5 to 5.1 cents per pound. Variations in costs are due to the size of the operation. These costs do not include the cost of the raw product nor the cost of advertising and selling the product.

Plans: Fieldwork in this project will be completed this season. A report on processing plant costs and efficiency is being prepared by the Idaho Agricultural Experiment Station.

MARKETING COSTS AND MARGINS FOR POTATOES ME

Problem: Provide information on the marketing costs and margins for potatoes from various producing areas sold in several major markets.

Program: The study of marketing margins for potatoes is a part of an over-all continuing program of work on marketing costs and margins conducted at the direction of Congress. It requires one to two man-years per year of professional Federal labor.

Progress: Costs were computed for four current methods of packing potatoes in 10-pound consumer bags. The method which required the lowest investment in equipment had the lowest costs for packing over the volume range from the smallest volume that may be packed up to about 20,000 hundredweight (200,000 10-pound bags) in one season. For annual volumes above 20,000 hundredweight, the so-called roll-around table, available commercially in several versions, had the lowest costs. The history of 10-pound bag packing in the southeast shows that the 20,000 hundredweight annual volume seldom would be exceeded.

The relative costs for packing and handling 100- and 10-pound bags were compared to assist packers in establishing relative prices for these containers. For those costs which could be readily computed--materials, labor, and equipment, and extra potatoes--the extra cost per hundredweight for 10-pound bags was 91.5 cents, if the annual volume was 2,500 hundredweight in 10-pound bags and ranged to 56.6 cents for 40,000 hundredweight.

Plans: Cost analyses will be made for other packinghouse operations which will complete the project on marketing costs and efficiency in early crop potato areas.

Marketing margins for late-crop potatoes marketed in four major cities have been computed for a five-year period. Trends in marketing costs and margins are being analyzed and a report is being prepared.

Publications: An Analysis of Costs for Packing Potatoes in 10-pound Bags in the Southeast." George L. Capel and R. E. L. Greene, Fla. Agr. Expt. Sta., Agr. Mimeo Rept., 1959.

G. Price, Supply, and Consumption

PRICE, SUPPLY, DEMAND, AND OUTLOOK ANALYSIS FOR POTATOES AEC

Problem: Growers, processors, and handlers need more information about the forces which influence supply, demand, price, and utilization of potatoes, to facilitate more orderly production and marketing of the crop.

Program: A continuing long-term program of basic economic research relating to supply response, and supply, demand, price, and consumption relationships, and a continuing appraisal of the current and prospective economic situation for potatoes, involving one Federal man-year annually.

Progress: During the past year, market situation and outlook work was continued. Frequent appraisals were made of the current and prospective short-term situation as to supply, demand, price, and consumption of potatoes. Results of these appraisals were published in quarterly issues of the "Vegetable Situation" and the "National Food Situation" with brief reviews in monthly issues of the "Demand and Price Situation." Basic statistical series were maintained, revised, and extended.

Work on price and consumption analysis for seasonal potato crops is continuing. The basic factors that appear to affect consumption, i.e., price of the given seasonal crop, price of other potatoes on the market, consumer income and marketing costs have been interrelated in this analysis. These studies have been made for both pre-World War II and post-World War II periods to determine if differences exist in the importance of the effects of these factors in the two periods.

Preliminary results indicate that supplies of fall crop potatoes carried over into spring are becoming relatively more important in their net effect upon the price of winter, early and late spring potatoes. Also these

results indicate that for most seasonal potato crops, consumer income and marketing costs have become less important in determining changes in consumption than formerly. In the postwar period there appeared to be some relation between income and price of winter, early and late spring potatoes. But only for late spring potatoes was the income effect statistically significant. As income increased, the price of late spring potatoes decreased.

Work was initiated to determine the factors which influence growers to hold fall crop potatoes in storage for spring marketing. Preliminary results indicate that January 1 stocks adjusted for Government purchases or diversions is a significant factor, and ratio of expected price to current price, and intended late spring acreage follow in importance.

A popularized version of the technical article on effect of price on potato supply, published in the October 1958 issue of Agricultural Economic Research, was prepared and published in the Vegetable Growers Messenger.

Plans: Supply, demand, consumption and price analysis of seasonal potato crops will be completed and readied for publication in bulletin form. Continuing analysis and periodic reviews will be made of the market situations and outlook for potatoes.

Publications: How Prices Affect Potato Supply Today. Olman Hee. Vegetable Growers Messenger. May 1959, pp. 12.

The Vegetable Situation-AMS, Washington, D. C. (Quarterly)

The National Food Situation-AMS, Washington, D. C. (Quarterly)

The Demand and Price Situation-AMS, Washington, D. C. (Monthly)